POWER

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CANDID CHATS

CONCERNING UNDERLINGS

EXCESSIVE emphasis upon the value of executive ability in modern industry has made it hard for many good men in subordinate positions to think of themselves as underlings. The term is almost one of disrepute in some quarters, and has caused many heartburnings in its day. False pride about one's position in life is a waste of energy which had far better be applied in study and hard work and aimed to make one more useful to the world.

The man who "feels it" because some fur-coated director, making a hurried trip through his plant, treats him like an underling and possibly refers to him as such in talking with the visitors, had better cultivate a thicker skin, clench his teeth with a determination to become master of his work, and open-circuit the natural flow of that "I'm as-good-as-the-next-man" current which every citizen of this great country harbors within his veins.

There are few men who have gone up through the ranks to the highest positions who have not been snubbed more than once en route, and, while no one is asked to abate one jot or tittle of his self-respect on this journey, it doesn't take much reflection to convince him that the place to expend nervous energy, ambition, and determination is on his work rather than in envy or in hostile lucubrations regarding people who seem to be more fortunate.

Just this simple plan of buckling down to work and perfecting one's efficiency therein is the policy above all others which will lead to individual advancement. Neither the aforesaid director nor the subordinate employee has any reason for patting himself on the back at the expense of somebody else.

The average director does not know a turbine rotor from an oil pump. The humblest coal passer can tell him something worth while about the way the fires act in different kinds of weather. The water tender, the oiler and the conveyor inspector, all are in positions to absorb accurate, detailed information of which the fellow voting to declare the dividends knows nothing.

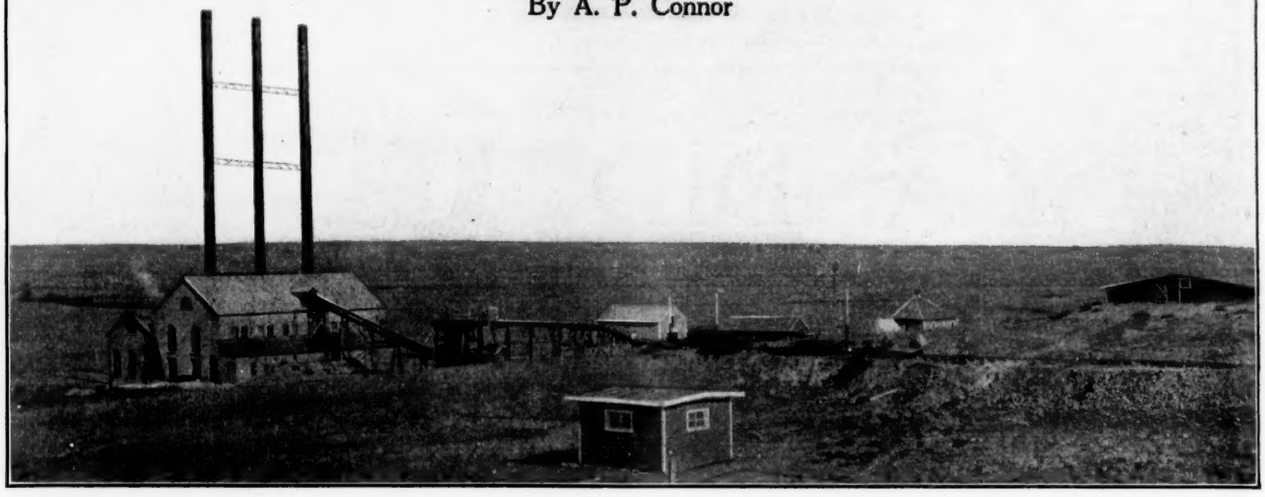
On the other hand, how many faithful subordinate employees know what fixed charges mean, or can tell the difference between a bond and a share of stock, or can explain why the company should be permitted to issue stock to purchase an additional boiler battery while it cannot properly capitalize the cost of putting in new tubes in that valiant old steam-raiser No. 7, which, after being forced on peak load for a decade, has to be given a well-deserved vacation?

No, this is the age of teamwork, and teamwork means cutting out all this self-consciousness and superiority talk and thoughts and opening one's eyes, hands and ears to learn everything possible from the other fellow plus cultivating a friendly tongue when the selfsame chap wants to learn something from you.

The man who looks down upon his subordinates through a fog of self satisfaction is not likely to last anything like as long as the fellow who is always ready to learn even from the most lowly employee in the works, and the chap who gets discouraged because he gets paid by the hour or by the week instead of by the month, and who feels that it isn't much use anyway because he's "only an underling," needs to pull himself together and realize that if he is in the business of generating power he is working in a field whose scientific and commercial possibilities are beyond the predictions of any single mind and whose opportunities for experiment, study, comparison, and imaginative thinking to a useful purpose are beyond the capacity of any individual and worthy of the best efforts of genius itself.—*By H. S. Knowlton, Cambridge, Mass.*

Federal Power Development at Williston

By A. P. Connor



SYNOPSIS—The fuel for the development power house is obtained within a few feet of the power house from the only mine owned and operated by the United States Government. Although the fuel is of a low grade it is burned efficiently by the use of a special type of furnace known as a semigas-producer furnace. Water, pumped by energy generated in this power house, is from the Missouri River, a special type of floating station being used for the pumping units.

It is customary in reclamation projects to dam a river and then deliver the impounded water to the arid lands by gravity, through suitable canals. In the case of the Government project at Williston, N. D., there was no practical way of following such a course. The Missouri is subject to considerable variation, and it flows through lands composed of clayey alluvial soil. The width of the river at low water is about 480 ft. in the vicinity of Williston, and at high water about 850 ft. The difference in high- and low-water levels is about 16 ft., and the low-water depth of the river is approximately 4 ft. A masonry pumping station was out of the question, therefore a pumping equipment on a barge was used to meet the conditions.

The delivery pipe line to the pumping equipment, Fig. 1, consists of a length of pipe extended from the pump barge to the bank, where it joins the main delivery line. At each end of this pipe length a ball joint is provided, which permits the pipe to take the angle between the barge and the land connection without putting stress on the pipe. The main difficulty is in the adjustment of the length of the pipe from the barge to the delivery line proper. This pipe is made of several lengths of pipe solidly joined, with the ball joints at the ends. This variation in the length was caused by the river's cutting out the bank between it and the barge.

The operating equipment on the barge, Fig. 2, consists of four motor-driven centrifugal pumps, capable of delivering to the basin in which the water is to be stored 30 sec.-ft. of water each, under a 30-ft. head. The motors are of the induction type, three-phase 60-cycle 2000-volt. The pump suction pipes consist of cast-iron bell-mouths ending in collars that are bolted to the planking of the barge. Each two pumping units feed into a single delivery pipe line. Suitable panel work, transformers and control apparatus are provided. The incoming power line is stepped down from 20,000 to 2,000 volts. The barge is held in place by ropes and also by the delivery pipes. Because the floods washed away the banking, it became necessary to support the delivery pipes on a barge between the main barge and the bank.

Floating trees and other débris clogged up the inlets to the pumps. A screen was placed under the inlet underneath the boat, and a long rod running through the barge to the pumproom is arranged so that the screens may be moved up and down to disengage any débris that has collected on them.

The barge is protected from drift wood, etc., by a substantial boom consisting of 60 ft. of 24-in. pipe incased in 2-in. planking, and with bolted joints. Before the ice season sets in the barge is unhooked and floated to a point down the river, hauled up on the bank out of the way, to be returned to its position in the spring.

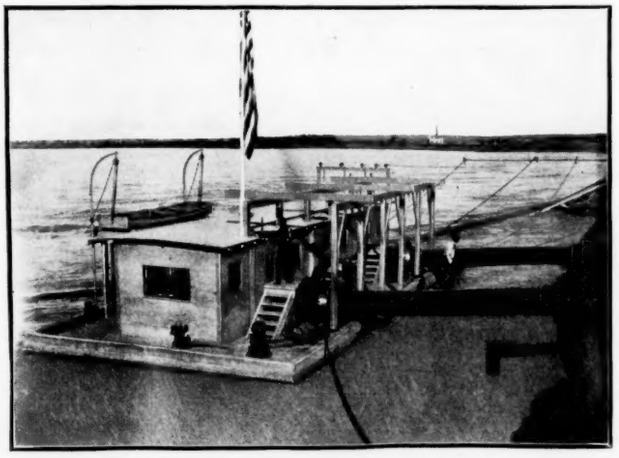


FIG. 1. FLOATING PUMPING STATION

The water pumped by the barge equipment is delivered to a 75x375 settling basin, in which the sediment, averaging 6 per cent., settles and so prevents the canals of the system from filling up with mud. A siphon arrangement adapted to suck up the mud at suitable times and return it to the river is installed at the basin. The difference of 25 ft. in head permits this to be done without difficulty, provided the joints of the siphon are kept tight.

The water distributes from the settling basin into the canals and is then used to feed the farm lands, and also to supply the water requirements of the power station, situated about two miles from the barge. At a suitable point the water in the canals is redistributed through another pumping station to another irrigation district. This pumping station is shown in plan and elevation in Fig. 3, indicating the apparatus in general used therein.

Before the water is used in the power station for boiler feed it is treated in a water-treating plant and stored in two tanks. The river water is used when it is available, and is converted into nonscaling boiler-feed water by feeding hydrated lime and soda into a tank containing the raw river water; the whole then passes into a second tank to settle. Well water is used about nine months of the year for the boilers, and it is also treated with a mixture of hydrated lime and soda in one tank, from which it passes to the second tank to settle before using.

The power station (see frontispiece) is situated 500 yards from the mouth of the only mine owned and operated by the Government and obtains its fuel at a cost of $1.78 per ton. The manner in which the coal, or lignite, is delivered to the power house is interesting. The mine mouth is at a high level with respect to the power house, and the grade in the mine is not great. Horses pull the coal cars out of the mine to a trestle on which they run by gravity to a tipple. The coal then passes through a crusher to a conveyor, Fig. 5, that takes it to a screw conveyor in the power house, where it is distributed uniformly in the coal bunkers. These have a capacity of about 500 tons.

The coal may be dumped on the floor in front of the boiler furnaces and then shoveled in, but another method is generally used. This consists in providing a partly manual and partly mechanical stoker made up of a deflecting plate having a convex form and mounted on the boiler fronts over the furnace doors. This plate is mounted on a shaft that can be turned to many angular positions by means of a handle. The plate is housed in, and a duct running from the hoppers of the coal bunkers to the housing serves to bring the coal to it. A hole is made in the brickwork of the boilers for each boiler furnace and the plate is extended to it. In a suitable position in the latter is placed a fourbladed motor-driven fan that catches the lignite, or fuel, as it comes down the plate and throws it into the fire or furnace. The speed of the motor is varied according to the distance it is desired to throw the fuel into the furnace. Angularly moving the plate causes the direction of the thrown fuel to change also, and thus the distribution of the coal or lignite can be made to suit.

Eight 260-hp. water-tube boilers supply the steam used in the plant. They are fitted with so-called semigas-producer type furnaces. These were deemed best for the coal used, which is a brown lignite containing about 40 per cent. of moisture and 8 per cent. of ash. In Fig. 4 is shown a side and front section of a boiler and furnace. The grates are deep-set, and there is a contracted space between the bridge-wall and the end of the prolonged firebrick arch. The grate is 21 in. below the lower edge of the firing door. This is to permit of carrying a thick fuel bed and to enable the fireman to note its condition easily. The solid fuel is gasified on the grate, and the gases pass the highly heated arch into the combustion chamber where they burn. The necessary air for the combustion enters through the openings *A* in the bridge-wall. This air is heated by means of coils *B* to about 250 deg. F., and is forced in under a pressure of about 1 in. of water. The location and direction of the air jets are such as to cause considerable mixing of the combustible gases and air. Some air also enters through the openings *C* in the roof of the furnace. This air consists of leakage through the outside wall into the air space that envelops the firebrick lining of the furnace. Although there is some combustion above the fuel bed, the greater part of the gases burn below the contracted arch and back of the bridge-wall. The rate of combustion is about 25 lb. of coal per square foot of grate per hour.

The air added through the bridge-wall is forced through the duct *D* into the upper half of the chamber *E*, and then to the preheating coils. The air passes through these coils to the other side of the boiler setting, where it is turned by means of a metal-sheet chamber into the lower half *B* of the coils, through which it flows back to the same side of the boiler from which it started. It then flows through the duct *F*, which takes the air into the upper tunnel in the bridge-wall, a damper *G*

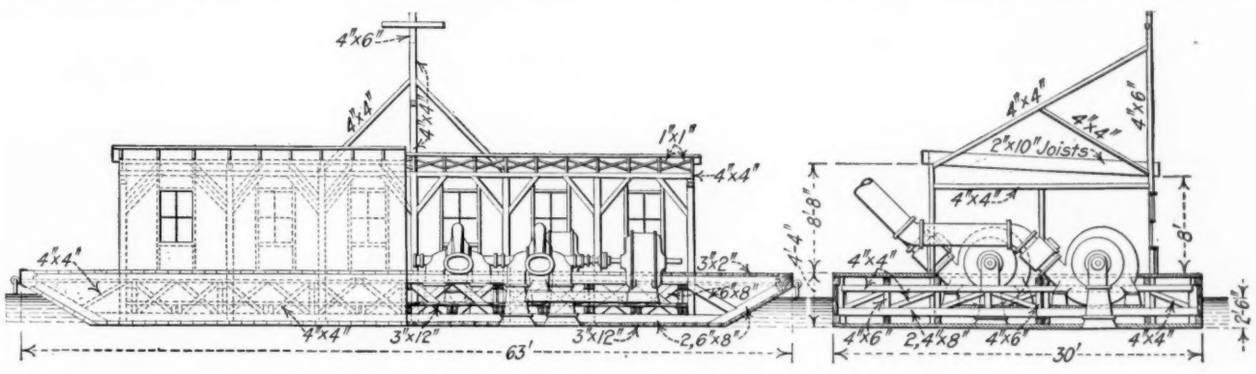


FIG. 2. HALF LONGITUDINAL AND CROSS-SECTION OF THE INTAKE STATION

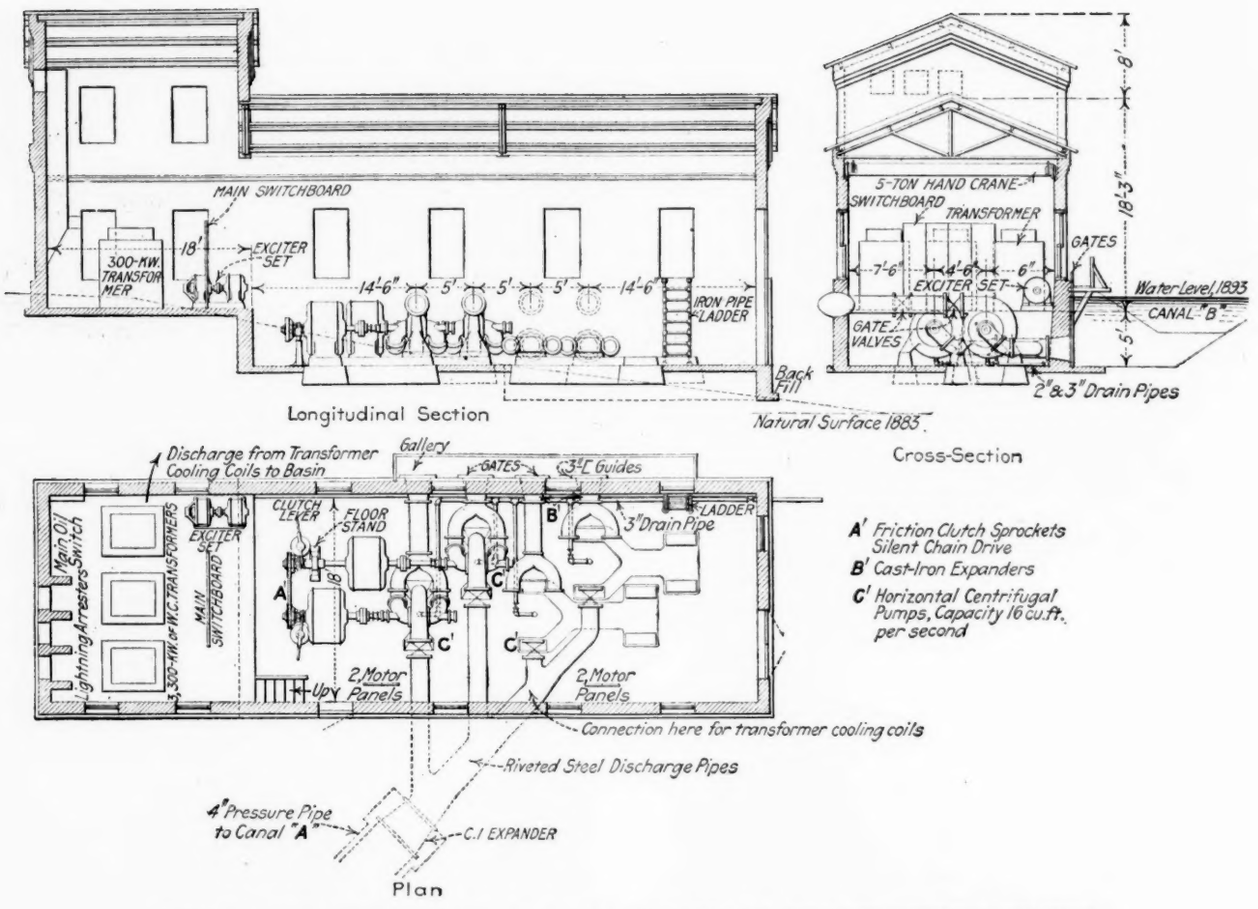


FIG. 3. PLAN, LONGITUDINAL AND CROSS-SECTION OF THE SUB-PUMPING STATION

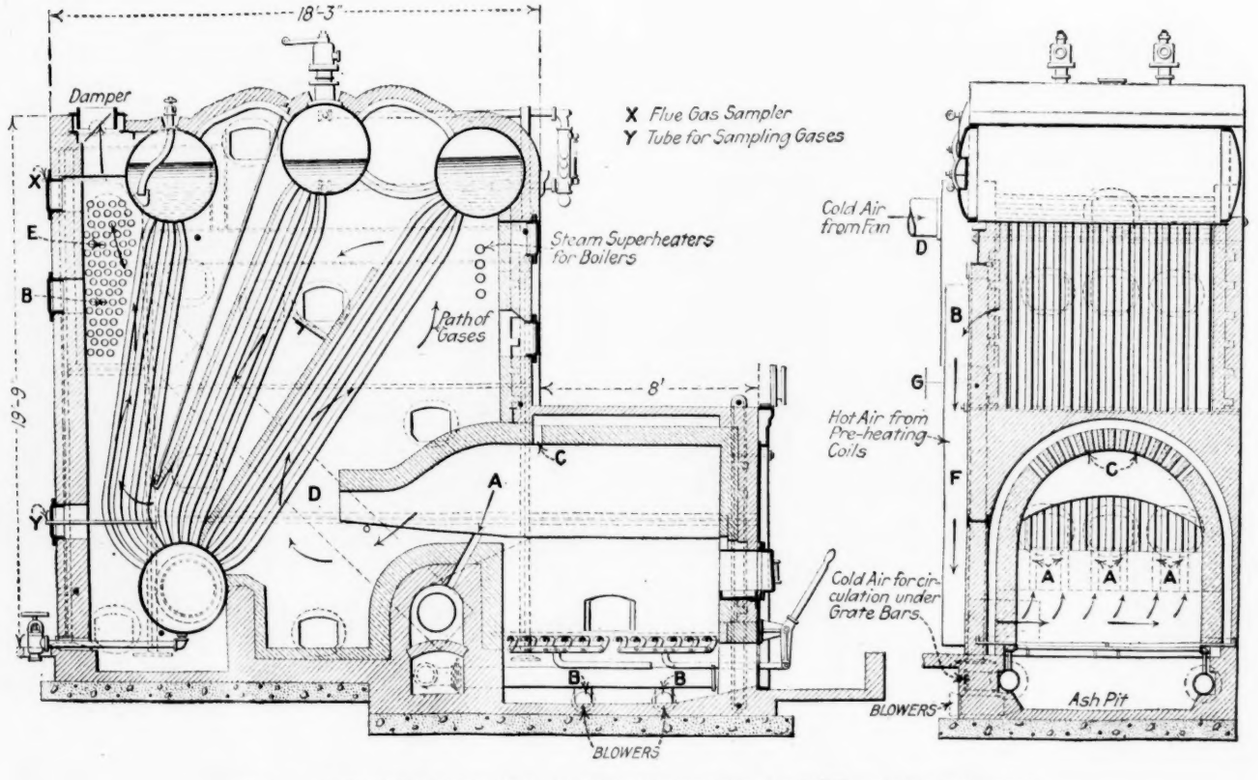


FIG. 4. VERTICAL SECTIONS, SHOWING DETAILS OF THE BOILER SETTING

regulates the air supply. Dumping and shaking grates are used.

Tests have shown that this lignite will burn satisfactorily if a strong draft and a large combustion chamber are provided.

The boilers are used in sets of two, and each set now has a stack 54-in. diameter and 135 ft. high, made of ½-in. iron.

Details of the Power-Plant Equipment

The power equipment, Fig. 6, of the plant follows standard lines, there being one 700-hp. and two 400-hp. turbo-generator units generating current at 2,200 volts, three-phase, 60 cycles. There is also a direct-connected engine-driven exciter set with a direct-current generator at one end of the shaft and an alternating-current generator at the other, so arranged that either can deliver the required power. This enables current to be supplied for the needs of the station, such as for the conveyors, etc., without starting up one of the large turbines. The condenser used for the steam-driven machines is of the jet type that permits the steam to mix with the cooling water.

A 5-ton crane is provided in the station for handling heavy material. The switchboard is of the standard type. The circulating and air pump for the condenser is of the steam-turbine driven type. The pumps of the pumping station at the power plant are driven by steam turbines, the steam being fed from the power-house boilers. The pumps are protected from rubbish by two sets of ¾-in. mesh screens in series. This arrangement permits a screen to be removed at any time for cleaning, as the remaining one will protect the pumps. A grating of iron bars spaced 2 in. apart catches the heavier drift before it reaches the screens. Another screen is used across the opening leading to the suction wells.

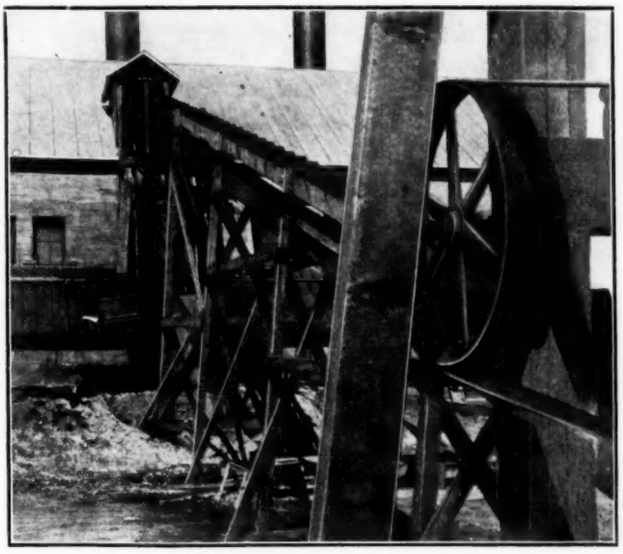


FIG. 5. COAL-CRUSHING AND CONVEYING APPARATUS

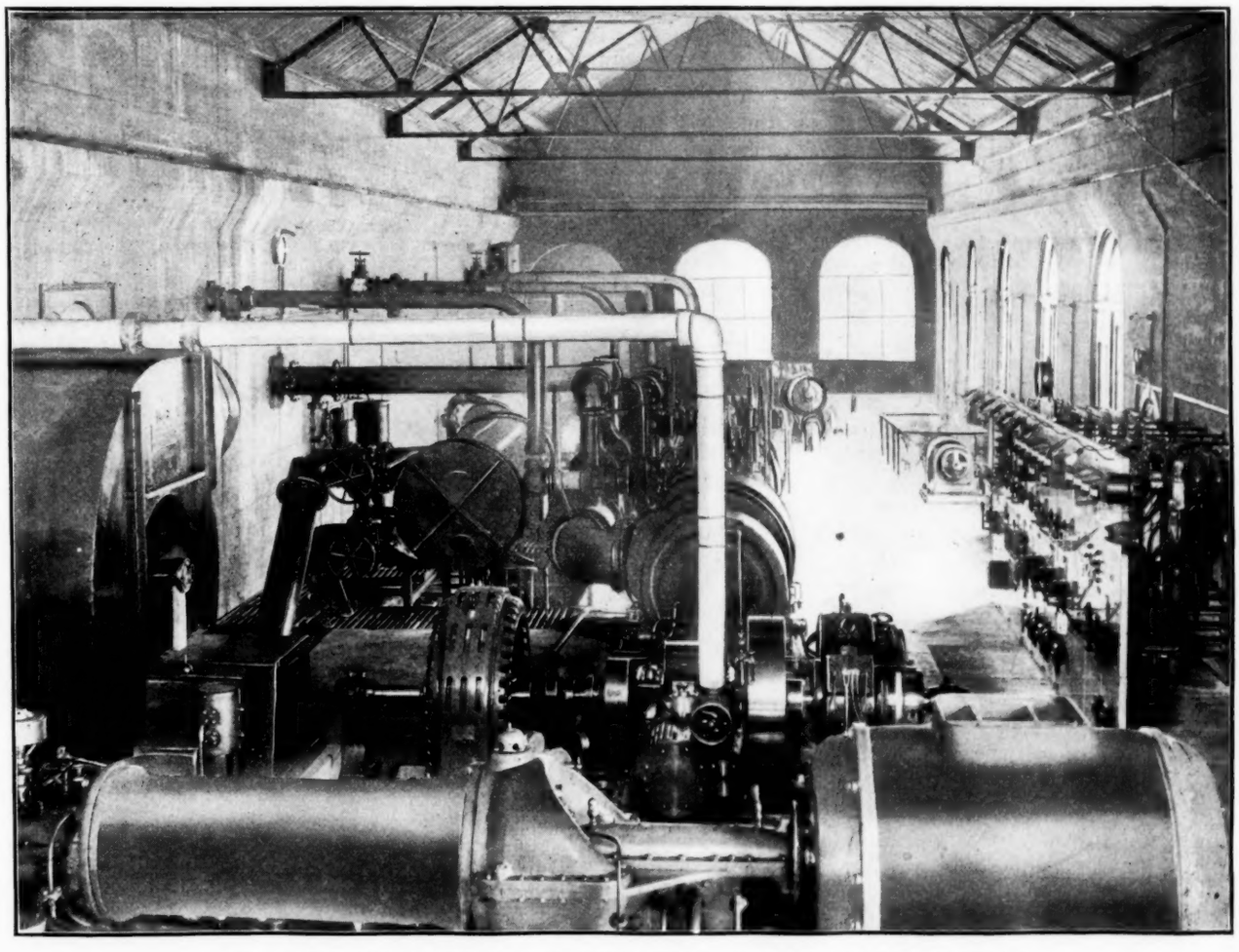


FIG. 6. INTERIOR VIEW OF THE WILLISTON DEVELOPMENT POWER PLANT

The power from the power station is transmitted over a wooden-pole transmission line, at 22,000 volts, to the various pumping stations of the project and to the towns that have use for the surplus electricity. Transformers are provided under usual conditions, as required. Power is developed throughout the year. In the summer season it is mainly used for the project itself and in the winter for the domestic and commercial purposes of the citizens on or about the project.

The total length of the canals of the project is about 135 mi. Some of the pumping units are 28 mi. from the power station. About 8,200 acres is to be eventually watered under this portion of the project, but the total on the whole will be over 12,000 acres.

Heat Maladies of Marine Diesels

By R. W. Crowly

SYNOPSIS—The operating conditions to which a marine Diesel engine is subjected are productive of large temperature differences within the metal, thus setting up internal stresses. The advantages and disadvantages of governors in this connection are set forth and the shortcomings of the two-stroke-cycle engine are discussed.

Ocean-going motor vessels are not lacking in the world's tonnage, but they aggregate a very small part of it. The oldest has not yet passed its fourth year, and the most powerful has only 1,650 b.hp. per shaft. The best has a fine record, but the worst supplies a shocking story. Within these bounds there is a maze of experience, where some firms successfully find their way, where others become discouraged and retire, and where unfortunately some try to break through ruthlessly, damaging themselves and bringing discredit in greater or lesser degree upon the motor-ship movement.

The fault has been almost invariably that the designers would not learn from the endeavor of others. Men who were saturated with Diesel-engine experience did not absorb even the fundamentals of marine engineering, while others who had built engines for steamers of the most varied types did not acknowledge the respect due problems in Diesel-engine construction. If in this country the marine Diesel is to escape the checkered youth from which the stationary oil engine of that type is not yet altogether free, there must be no repetition of the blunders for which many European manufacturers have paid heavily.

Marine Practice More Severe Than Land

The principal difference between marine and land conditions that exert such a far-reaching influence upon the performance of Diesel engines is that in the former the engine sooner or later operates under conditions that have not been taken into account in the design. A fictitious value has grown up around the tests made on the floor of the erecting shop. If there are faults in a new design, some of them can be made to appear by shop trials, but with a standard design the tests are no more than a check upon the accuracy of the inspection work and upon the quality of the fitting or the final hand-work. With every sliding surface clean and true, every joint tight, every bolt and screw firm, clearances just right, everything lined up, balanced and adjusted by skilled men, with all pipes, ducts, passages and spaces free and clear and with chosen oil, fuel and water, the engine turns under drawing-board conditions. But in regular operation dust and dirt will wear the sliding surfaces, packing will burn, bolts and screws will become loose, clearances will increase, parts will get out of line, out of balance and out of adjustment, pipes will choke, ducts will clog, passages and spaces will become corroded, oil may be foul because the filters are not clean, the fuel may be of low grade and the water will be dirty; not all at the same time nor uncared for, but singly and by twos or threes developing conditions that upset the designer's calculations. When the manufacturing conditions have proved thoroughly reliable, the firm can dispense with the shop tests. Manufacturers that do not admit these truths, at least in application to themselves, generally waste money and bring ill-fame to the industry.

Experiences of Some Successful Builders

In European development of the Diesel engine for ocean-going service two firms have been notably successful, and they were both marine-engineering companies that had been licensees under the original Diesel patents and had constructed stationary Diesel engines for about 10 years before entering the marine field. How these people view even the preliminary sea trials can be gathered from a couple of instances which will be mentioned. It happened on one vessel sent to sea for a short trial that the compressors on both main engines gave trouble in the first six hours. No efforts were made to remedy the fault, because it was considered that if failure took place under the best conditions there would be failure when the ship passed from the careful attention of the builders. These compressors, purchased for motives of economy from a firm that specialized in air-compressing machinery, were torn out, and the engine builders delayed the ship six weeks while they rushed the building of more expensive compressors of their own design. The cost of the loss did not count; there was no haggling, no effort to deceive themselves or others. Now, it so happened that other marine-engineering firms building Diesel sets under royalty from a respected company that had done well with stationary engines encountered the same trouble with compressors of identical origin. They did not have sufficient Diesel-engine experience to know what further trouble was foreboded by the first compressor failure, and after repairing the damage, sent the ships to sea. Each of the four ships reached port in a crippled condition after a slow passage.

Another example of the attitude bred by the combined marine- and Diesel-engine experience is that one of the two successful firms referred to does not now give its engines any further trial than four hours at sea, understanding full well that no shop tests, but only hard service, will discover whatever latent defects may exist. By contrast may be mentioned how another firm, with the

assurance born of a very slight familiarity with small engines for service in sheltered waters, fussed with two large engines on the test floor for 12 months before installing them in the vessel and then had the machinery thrown back on its hands when the ship finally completed its first round voyage, during which eight weeks had been spent under repair in port.

There are on land certain classes of power plants where almost continuous operation is practiced throughout long periods. If such engines are loaded to capacity they will be doing what marine engines do in fine weather. However, engines for stationary work are built in standard series, and manufacturers frequently alter the nominal rating to suit the plants on which they bid. Thus a single-cylinder engine capable of developing 180 b.hp. at full load may be sold for an installation that requires a maximum of only 160 b.hp. Whenever the full load of a plant does not call for the continuous maximum rated power of a Diesel engine, the performance of the machinery in protracted and uninterrupted operation should be faultness. When the engine is operated, however, at its real full power without relief, then the design must be exceedingly good if the logbook is to be free from blemishes.

Speed vs. Power to Drive Ship

A ship's engine nominally never has the advantage of being assured an underload. The propellers are designed to make use of the full power at a determined number of revolutions, the shipbuilder seldom erring on the low side with his contract speed. Occasionally, however, the ship's lines and the propeller design may prove more favorable than the estimate, leaving a margin of power at the contract speed. What happens? A few more revolutions to the engine, the margin of power is wiped out, the ship travels a little faster, and the shipbuilder gets extra credit for his work. Moreover, it is not a straight-line ratio between power and engine revolutions, but a cubical ratio.

It is true that none but express steamers are habitually driven right up to contract speed, and by keeping the engines at three-quarters or seven-eighths of full power in good weather, the chief engineer can maintain nearly full speed while economizing in fuel and saving wear and tear on the engines. If the weather were always fine, the engines would not have a hard task. There are times, however, when for days at a stretch the ship will meet head winds or heavy seas, and then the engines have to be pressed harder. Let us see what they have to do then.

First and foremost there is the influence of the continuous heat in the cylinders. By the constant flow of water through the jackets it is intended that the walls of the combustion chamber shall be kept uniformly cool. Owing, however, to variations in the thickness of the metal, as at the flanged upper end of the cylinder liner and around the many cored spaces in the cylinder head, the cooling never is uniform, and this is aggravated by the difficulty of making the water flow with equal freedom throughout the intricately disposed space of the jacket in the cylinder-head casting. It is thus unavoidable that there shall be local temperature differences in the walls, and these will be greater as the change of thickness is more abrupt and the metal less exposed to the circulation of water. While this relates to the design, the operation intensifies the effect according to the load and its duration.

These local temperature differences have little importance unless the expansions that they tend to produce are opposed to such an extent that the internal stresses arising therefrom overcome the resistance of the metal to them. The collapse of the metal under the strain may occur during operation of the engine or when the metal is contracting unevenly as the engine is cooling after being shut down. And it will be clear that the rate at which a local temperature difference grows will be faster in some cases than in others, being influenced by the variation of the different factors. Also it will be at a diminishing rate, because with the increasing temperature of the metal there will be a retardation of the acquisition of heat and an acceleration of the cooling. Plainly also, equilibrium between the acquisition of heat and the cooling may occur before the temperature difference becomes large enough to cause trouble.

Intermittent and Continuous Work

Thus an engine may operate satisfactorily at full load for 6 or 8 hr., perhaps even for 24 hr. or for a couple of days and nights without any relief and be used in intermittent work of that character for several years without breaking down, while it may be unsuitable for more protracted runs under heavy load. Days may pass with the engine running steadily under a full load before the full range of local temperature differences has been established. A convincing demonstration of this was afforded during some well-defined experiments by one of the big European manufacturers, when it was found that under the particular conditions established the cylinder covers all cracked within very close to 250 hr., the original covers and the renewals alike cracking with almost mathematical regularity.

The average ocean-going cargo carrier requires its machinery to turn steadily at nearly full load for a period seldom less than 15 days and nights, and this of itself involves heat conditions much more trying than are usually encountered in stationary practice.

Conditions Imposed by Bad Weather

So far the discussion has been confined to fair-weather conditions; operation under conditions of less favorable weather will now be considered.

Assume that the vessel is pitching heavily, with her propellers at one moment churning the air and at the next buried in the sea. Whether the engine has a governor or not, this extreme fluctuation of the load will be a source of strain. Marine engineers are not of one mind about governors. Without a governor the engine will alternately race and slow down; with a governor the racing will be checked, but the intermittent drop in speed will be greater. If there be no governor on the engine, the charges of fuel fed to the cylinders will remain constant at the amount determined by the position of the fuel-regulating lever, and when the propellers are clear the speed will rise; but in the few seconds that will elapse before the blades again become immersed, the increase in speed cannot be very large, and the same inertia forces that prevented dangerous racing will help to check the fall of speed when the full load of the deeply buried screws comes upon the engines. A governor will, on the contrary, vary the fuel charges with the load, and

thus when the propellers emerge, the fuel supply will be cut off and the engine speed will not increase more than a couple of revolutions or so; but directly the load comes on again, the engines will slow down considerably because momentarily there will be insufficient fuel to give driving power.

Those are the alternatives, and of the two the absence of a governor is the preferable as regards the heat conditions within the engine. Almost paradoxically, as it may seem to those unacquainted with the other pros and cons, the majority of engine builders prefer the governor, however. In this event there is a choice of two systems: The regulating lever may act directly upon the fuel supply, thus limiting the control of the governor to a diminution of the fuel charges, or it may act through the medium of the governor by altering the speed at which the latter will take effect, the measurement of the fuel charges being then a governor function. In both instances, the engine will be subjected to excess heating.

The commoner of the two systems provides for the regulation of the fuel directly by the lever, with the governor standing by. If, when starting the engine, one moves the regulating lever directly to the position for normal full speed, the relief-valves which, though unusual in land practice, are orthodox fittings of the marine Diesel engine, will begin to pop. That is evidence of pressures above normal, which arise from advanced combustion.

Timing of the Fuel Valves

The opening of the fuel valves is timed to start the admission of the fine oil-spray sufficiently early to have the progressive combustion providing burnt gases to maintain for a short period a constant pressure in the increasing space left above the downward traveling piston. In the engine of a cargo ship the fuel-valve will open about 3 or 4 deg. before dead-center: in a submarine engine the advance angle may be 7 or 8 deg. The higher the engine-speed the earlier will be the opening, because the angular measurement is not an absolute standard but a relative standard, the basic factor really being time.

When the angle has been determined for any particular engine with a given fuel, no trouble will normally be found from advanced ignition at any of the speeds within the range of that engine. Although the time corresponding, for example, to 3 deg. is doubled when the revolutions are reduced from 120 to 60 per min., a compensation is afforded both by the compression temperature being lower (there will be more heat conducted away through the jackets during the slower compression stroke) and because the injection air, finding less obstruction owing to the reduced charge, will enter in larger volume and cause greater chilling by its expansion. The influence of the latter effect can be appreciated by the realization that if one diminish the fuel charge to such a small quantity that ignition will just fail with the full blast pressure, then the firing will be resumed if one discriminately reduces the blast.

If, instead of feeding to the engine at reduced speed the diminished fuel charges appropriate to that speed, one should supply it with full-load charges, then there are possibilities of advanced combustion and increased pressures. That is what happens when an engine is started with the fuel-regulation lever in the full-load notch, and that is why the relief valves blow. This is also what frequently happens when a motor ship is pitching with her propellers clear in heavy weather, the governor cutting in and out, and the fuel-regulation lever well up the notches.

Indicator diagrams taken during the early strokes of an engine that has just been started show pressures up to 700 and 800 lb. There is no danger in the pressures themselves, the engines are built to withstand them and to withstand much greater pressures; but concurrent with the increased pressures are increased temperatures, and they are potent for trouble. To have these increased temperatures in the cylinders recurring every time the governor acts to prevent racing, perhaps two or three times a minute, not for a half-hour or an hour, but perhaps the whole day or several days, is a condition with which a land engine never has to contend.

Heat Conditions Without Governor

Where no governor is fitted and the fuel charges are determined solely by the position of the fuel lever, the result of racing will be that the engine will perform a greater number of power strokes while the load is removed from the propeller. Taking into account that, to reduce the racing, the fuel lever will be set back to reduce the fuel charges, it will often happen that the engine will not race from its reduced speed beyond the normal full speed, in which event no overheating will occur. Directly the engine races beyond normal full speed, the increased heating due to the augmented number of power strokes will introduce conditions akin to those of overloading. And in measure with the amount by which the sudden return of the load will cause the speed to fall below that normally corresponding to the particular position of the fuel lever, so will there be an effect comparable to that of governor action. All in all, the cylinder castings will not be subjected to much, if any, extra stress when an ungoverned engine is intelligently watched in bad weather. However, to prevent misconception, let it be repeated that there are other factors in the governor controversy, and since most firms favor the governor, so do most Diesel engines have to suffer the consequent heavy stresses in bad weather.

Effect of Rhythmic Speed Variation

Apart from racing there is another case of persistent speed fluctuations that should not be overlooked. In weather that does not bring the blades, or even the tips of the blades, above water, the speed of the engines may see-saw in rhythm with the rise and fall of the ship on the seas. This means nothing to a steam engine, but to a Diesel engine it entails the feeding of fuel charges which, though appropriate to the higher speed, are in excess for the lower speed, in a manner similar to, but with less effect than in, the case of the governor cutting in and out. Although the excess pressures thus produced will not cause the relief valves to lift, they will produce more heat than normal operation and will render the engine more susceptible to other evil influences.

Assume, for instance, that the fuel feeding has become slightly deranged during such weather, so as to disturb the equalization of the fuel charges to the different cylinders, and as a result some of the cylinders are not doing their proper share of the work. In such an event the other cylinders will carry an overload. Overloads mean greater heat and sometimes very serious heat, and over-

loads in individual cylinders are the explanation of many cracked cylinder heads and pistons.

Irregular fuel feeding has to be combated also in stationary engines, but in marine practice its conjunction with other adverse influences may make it more serious. Before it becomes grave it should be detected by the unsteady running of the engine, and in the daytime at least by smoke in the exhaust.

A further cause of injurious heat accumulation which may develop after a marine engine has been in service many months is a consequence of the use of salt water for cooling. Fresh water is out of the question for the cylinder jackets and crown jackets because the large quantities required cannot reasonably be carried by the ship nor can evaporators for the purpose be logically proposed. For the piston cooling, however, fresh water is desired by most manufacturers, but that is an objectionable requirement that will have to be abolished. Salt water is not really unsatisfactory if in practice the circulation is maintained according to the strict intention of the engine designer. Below 100 deg. F. it deposits almost no scale, and at 70 deg. F., which is a possible outflow temperature in northern latitudes, it is as good as fresh water. The trouble, however, is that there is no real margin as a safeguard against the higher temperatures in stagnant pockets or corners, especially if the ship should trade much in such waters as the Red Sea or Persian Gulf. Once scale begins to form, it will deposit faster and faster, because the original defect will be intensified. If not discovered, it may result in a choked pocket or passage, which will produce or accentuate a local temperature difference that may be severe enough to cause fracture of the metal.

Stresses Serious in Large Cylinders

With increasing cylinder diameter the heat effects become more pronounced, not only because the heat volume augments much more quickly than the cooling surface, but also because the greater thickness of the walls of the combustion chamber gives greater scope for internal stresses in the metal. Thus a 30-in. cylinder developing about 350 b.hp. is much more of a problem than an 18-in. cylinder giving about 120 b.hp. With higher speeds the heat effects are intensified. For the sake of weight reduction, as in a submarine engine, one may shorten the stroke and increase the revolutions with a given cylinder diameter, and although the power will remain about the same, the more numerous power strokes will accentuate the heat stresses. Again, the two-stroke cycle will obviously magnify the thermal troubles. For instance, a 24-in. cylinder that will develop 200 b.hp. on the four-stroke cycle will give about 350 b.hp. on the two-stroke cycle, other conditions being unaltered.

The most favorable engine is the slow-speed four-stroke-cycle mercantile marine type, and the most troublesome is the high-speed, two-stroke-cycle submarine type. Four years of motor-shipping have shown that in the slow-speed engines of cargo boats only a single incomplete success has been attained with a two-stroke-cycle engine, whereas the four-stroke-cycle type has shown numerous successes and not a single failure. Shipowners now show a preference for the four-stroke-cycle engine, and ships with this class of machinery preponderate in Lloyd's register. Only two designs of this type have been tried in ocean-going service, whereas six of the two-stroke-cycle class have been similarly tested. Not reckoning the licensees who still have to send engines to sea or counting the firms who have not proceeded beyond their experimental shopwork, there have been only four builders to share the four-stroke-cycle work, but thirteen have participated in the two-stroke-cycle efforts. No repeat order has ever been placed for a two-stroke-cycle marine engine in this kind of service, but some of the shipowners who have acquired four-stroke-cycle engines are building fleets of such vessels and even selling some of their steamers. Up to the present no two-stroke-cycle engine above 800 b.hp. has satisfied marine conditions, and all except two sister engines of even that relatively low power have had serious troubles: the four-stroke-cycle engines of more than double that power have answered every requirement. Some two-stroke-cycle engines have even been removed from the ships in which they were installed. All this has been recorded in the reports from Lloyd's.

Navy Prefers Four-Stroke Cycle Engines

In the submarine-engine category the experiences have been similar. In the latest specifications of the United States Navy preference is given to the four-stroke-cycle engines as a result of the poor showing of the two-stroke-cycle engines that had been ordered in previous years. In the English and French navies only an occasional two-stroke-cycle engine is ordered, as an encouragement to experiment; the specifications regularly call for the four-stroke-cycle type. Even in Germany, which more than any other country has attempted to solve the two-stroke-cycle problem, a reversion to the four-stroke-cycle type was becoming manifest before the war, and probably the latest submarines belonging to that power have in many cases this type. How often the capture of German submarines has been due to the breakdown of two-stroke-cycle engines is unknown, but such cases must form no unimportant number among the total captures.

In conclusion it may be of interest to relate an incident of the present war when a motor ship and an enemy submarine sighted each other. The motor ship had a contract speed of 11½ knots, and, as the story goes, when the skipper first sighted the enemy, there was sufficient distance between them to promise a chance of escape by crowding on full power. Drawing the fuel levers on both sides to their full range made very little difference, adding only a few revolutions to the engines. Therefore, the engineer, realizing that something had to be done quickly, knocked out the pins from the ends of the fuel-lever quadrants and was able thereby to pull the levers far over until the pumps were almost heaving the fuel solidly into the cylinders. Fuel pumps always have a capacity greatly in excess of full-load requirements, this being desirable for reasons that concern the pumps. The revolutions bounded up until the ship was making a good 14 knots, and with this the submarine could creep up only very slowly. Down below, the engineer watched anxiously as the engines labored under the terrific overload, pounding until it seemed as if the bolts were visibly straining. He knew that could not last long, and at every minute expected to see the cylinder heads commence to go. At the end of an hour the submarine had gained only a trifle, but it did not seem possible that the engines could live through even another hour and the ship seemed doomed. But what was happening in the engine room of

the merchantman was undoubtedly having its counterpart in the body of the naval boat, for she, too, had Diesel engines, which probably were of the two-stroke-cycle type. So this gamble with the fate of a ship was really a contest of Diesel engines. Luck had it that the submarine commander gave up the chase after two hours. Who knows whether because he feared for his engines or because his engines actually failed? If he could have kept up the race he would have overtaken his prey, for he was faster in any case, and those staunch engines of the cargo boat could scarcely have stood together under the terrible strain much longer. As it was, they acquainted themselves superbly, and when opened up in New York harbor at the end of the voyage the only damage found was a cracked cylinder liner. The engineer was doubtless proud of those engines because of their dependability.

How Much Will We Save?

By Carleton W. Hubbard*

SYNOPSIS—An engineer does not have the ability to figure and is always "stumped" when he is asked what the saving will be for any particular change. A friend shows him how to do some figuring by using a chart.

John Young, the engineer at Easton & Weston's, was an elderly man who had served his time in those days, happily now distant, when an engineer was supposed to keep the engine oiled and the brasswork polished and was not required to know how to "figure" much on any of the many problems always cropping up in the operation of a power plant. John was far from lazy, and as years passed he came to see more and more the handicap that his lack of knowledge was laying on him. He worked long hours, nights and Sundays, and he was loyal to the interest of Easton & Weston, but Easton was dead and Weston was old and had practically retired, and the new men in the management didn't have the same confidence in John's recommendations that the older men had had. When some change or addition to equipment was put up to them, the first question always was "How much will it cost?" and this was rapidly followed by "How much will we save?"

John had been stumped by these questions before. He could generally answer the first one pretty well, but the second was too much for him. A general answer, such as "I don't know exactly, but it will pay you to do it," brought back the reply, "Well, we'll consider it." Twice had John gone up against that proposition, and both projects were still "under consideration." Moreover, he knew that neglect of them was costing the firm money. One of them was a simple matter of 43 lineal feet of covering for a new piece of 4-in. live-steam line.

"Anybody would know that that pipe ought to be covered, and those fellows up stairs keep asking how much we will save. It's a cinch I don't know how to figure it out, but I'm going to get someone to show me," mused John as he stood looking at the bare line. "Snyder, down at Johnson's mill, is a pretty good fellow, and I guess he'd help me out if I asked him. I hate to let him know that I can't figure it out, but I'd hate worse to have some 'wise guy' come in here and see that bare pipe."

It didn't take long to get Snyder on the phone. He was a younger man than John, had had a good schooling and was strongly interested in the educational work that one of the engineers' associations was doing. What was even better, he was always glad to pass his information along and so make it of the greatest possible use. Snyder gladly promised to help John. Six questions came over the wire in rapid succession: "What size pipe is it?" "Four-inch." "How long is the bare part?" "Forty-three feet." "What is the steam pressure?" "One hundred pounds." "What kind of coal do you burn?" Semi-bituminous." "How much do you pay for it?" "Three dollars." "Is the steam pressure on the pipe the same 24 hr. a day?" "Yes, and every day of the 365 days in the year."

"Hold the wire a minute, Young, and I'll give you the answer."

"Gee," thought John as he held on to the receiver, "it must be a cinch to figure that out if he can do it as quickly as that."

"Hello, Young," came over the wire; "that covering ought to cost you about $10, and the savings in one year would be about $42. Is there anything else I can do for you?"

"Yes; if I come down this afternoon will you show me how you figured that out? It is something I should know, but I don't."

"Sure thing; come on down, I'll be here all the afternoon."

Snyder had all his "dope" ready when Young dropped in that afternoon, and they started right in on the problem.

"You see, Young, like all other power-plant wastes this loss goes straight back to the coal pile. The amount of heat in coal is expressed in British thermal units, or B.t.u., as they are usually called. One B.t.u. is the amount of heat required to raise the temperature of 1 lb. of water 1 deg. Fahrenheit. Now a bare pipe will radiate 3 B.t.u. per square foot of surface per hour for each degree difference in temperature between the pipe and its surroundings, so that it is necessary first of all to get the area of the pipe, the temperature of the steam in the pipe and the temperature of the surroundings. You have 43 ft. of bare pipe, but we will figure the problem out for a pipe 1 ft. long and then multiply the answer by 43. Now look at this table:

Pipe Size	Sq.Ft. of Outside Surface of Pipe 1 Ft. Long	Pipe Size	Sq.Ft. of Outside Surface of Pipe 1 Ft. Long
1	0.345	6	1.732
2	0.620	7	2.020
3	0.916	8	2.252
4	1.177	9	2.538
5	1.451	10	2.816

"You have 4-in. pipe, so each foot in length of that pipe will have 1.177 sq.ft. of outside surface. Here's

*Second vice president, Fuel Engineering Co. of N. Y.

another table which gives the temperature of steam at different pressures:

Gage Pressure	Temperature of Steam	Gage Pressure	Temperature of Steam
175	377	100	338
150	366	75	320
125	353	50	298

"Your pressure is 100 lb., so that the temperature of the steam in the pipe is 338 deg. We don't know the temperature of the surroundings of this pipe, but if we take it to be 70 deg. F. the year around, we won't be far out of the way. The difference in temperature between the pipe and its surroundings is 338 — 70 = 268 deg. That means that each square foot of that pipe will radiate 3 B.t.u. for each one of those 268 deg. of temperature difference. The heat lost from one lineal foot of 4-in. pipe would therefore be 1.177 × 3 × 268 = 946 B.t.u. per hr. Now, by putting on a cover you could save 80 per cent. of this, so the heat that would be saved by the cover would be 946 × 0.80 = 757 B.t.u. per hr.

"You are using a semibituminous coal, and as fired under your boilers, each pound of it probably contains about 13,850 B.t.u. Not all of that heat gets into the

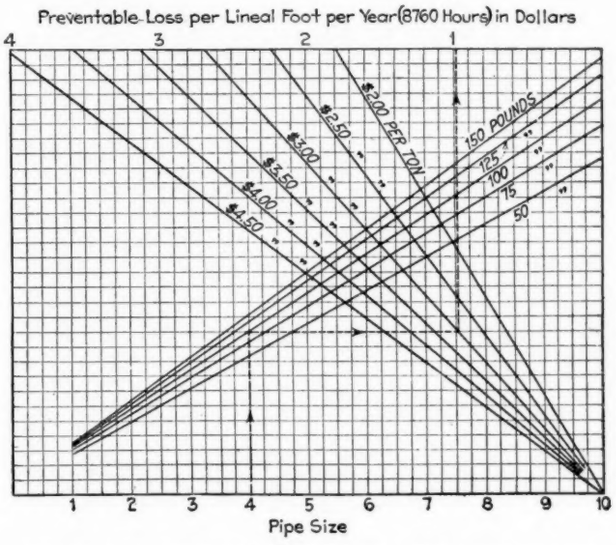


CHART FOR DETERMINING BARE PIPE-LINE LOSSES

In computing this chart the following assumptions were made: Temperature of air surrounding the pipe, 70 deg. F.; heat emission of bare pipe, 3 B.t.u. per sq.ft. per deg. difference in temperature; efficiency of covering, 80 per cent.; boiler and furnace efficiency, 65 per cent.; average semibituminous coal, having a heat value as fired of 13,850 B.t.u. Therefore, with other coals multiply the preventable loss by the factor 1.175 for anthracite and 1.04 for bituminous coal

water in your boilers—probably not more than 65 per cent., so that the amount of heat from your coal that gets into the steam is 13,850 × 0.65 = 9,002 B.t.u.

"Every running foot of bare 4-in. pipe is wasting 757 B.t.u. per hr. under the conditions at your plant. There are 8,760 hr. in a year, so that each year the preventable waste is 8,760 × 757 = 6,631,320 B.t.u. If you divide that by 9,000, it will give you the number of pounds of coal wasted. This is equal to 6,631,320 ÷ 9,000 = 737 lb. You're paying $3 for 2,240 lb. of coal, so the money value of 737 lb. of coal is (737 × 300) ÷ 2,240 = 98.7c. That is, each running foot of bare 4-in. pipe in your plant costs you an unnecessary 98c. a year. Your pipe is 43 ft. long, so the total preventable loss in your case is 43 × 98.7 = $42.44.

"That isn't very hard to figure, Snyder, but how did you give me the answer so quickly over the phone?"

"I didn't work it out as I have for you just now, but took if from this chart, which is worked out the same way, but covers a lot of different conditions. When you have the chart, all you have to do is to start at the pipe size, run up to the proper pressure line, then horizontally over to the proper price line, and then straight up to the top (see chart), where you find the answer." Snyder's pencil ran over the chart along the lines marked with arrow heads. "Ninety-eight cents a foot," he said. "That's what I did while you were on the phone. Then I multiplied it by 43, the length of your pipe. The answer was $42.44."

"How did you figure the cost of the covering so quickly?"

"Well, I have found that here near New York the cost of pipe cover in place can be estimated very closely by using this formula:

Cost of 1 lin.ft. of cover in place =
(Dia. of pipe in inches × 3.5) + 9

"In your case you had 43 ft. of 4-in. pipe, so all I did was to multiply 4 by 3.5 and add 9, which makes 23. That is the approximate cost in cents of a running foot of cover in place. You have 43 ft. of pipe, so if you multiply 43 by 23 you get 989. That's cents, so its $9.89, and I called it $10.00."

"Much obliged to you, Snyder. I guess I can answer their questions now, and when they see how soon that cover will pay for itself I think I'll get it in a hurry. I'd like to copy those tables so I'll be able to figure the saving when I want some more pipe cover. Do you mind?"

"Help yourself, and I'll have a blueprint of that chart made for you. If I can help you out any other time, don't be bashful about asking."

Two Causes for Engine Wrecks

By Hubert E. Collins

In the effort to determine the cause of flywheel explosions or engines otherwise wrecked, the investigators are often at a loss to know where to place the blame. In the event of flywheel explosions the governor is frequently smashed, and it is then hard to determine what its true condition was before the wreck. If no other fault is discovered, the governor will doubtless be blamed, if the wreck is plainly caused by high speed.

However, the engine might run away and be wrecked and still the governor be innocent of the fault. The wreck might leave enough of the governor intact to show that it was all right, and yet the evidence might show that the wreck was from overspeeding. Then the verdict would likely be, "cause unknown." One cause for such a wreck under these conditions is as follows:

In the power plant of an Eastern manufacturing company are two cross-compound high-speed condensing engines of the four-valve type. They are operated one at a time, the other being reserved as a stand-by. The larger engine had been in service for several months when the operator found that at times when the load was partly thrown off it would speed up and needed throttling to keep it down to speed; later it would speed up before the load was put on, so that it had to be throttled. The trouble finally became so bad that the engine was throttled all the time, with or without load. It would control only when running noncondensing.

The governor was blocked out so that the eccentric had the minimum throw and the valve the minimum travel. As the governor in question throws the eccentric across the shaft, the valve should travel only enough, with the eccentric at the position of least throw, to take up the lap, but not to open the port at all during the revolution of the engine. With the governor blocked out, a complete revolution was made while the steam valves were watched. One was found to be slightly open all the time. This explained the cause of the engine's speeding up; for

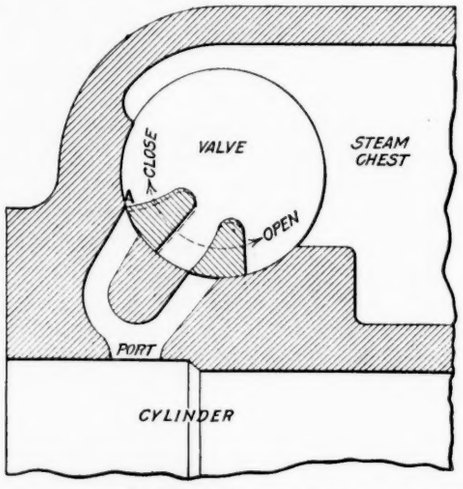


FIG. 1. CROSS-SECTION OF STEAM VALVE

although the governor acted freely and gave the required travel, the valve did not cover the port at the time of maximum speed and allowed steam to enter the cylinder and give the impulses required to carry the speed beyond the limit.

The remedy would ordinarily be to give the steam valves enough lap to cover the port at all points of the stroke with the governor blocked out. But here is the point where this particular valve differs from most others. The valves are of the Corliss type. A cross-section of the steam valve at one end of the cylinder is shown in Fig. 1. The governor and valve gear are so designed that with the weight blocked against its outer stop the eccentric center is so close to the shaft center that there is no throw and the valve edges are line and line with the port edges, as shown. This does not represent exactly the engine in question, but the principle of its design is the same. One port is well toward the center line of the valve opening, as indicated. Inspection showed that the valve chamber had worn down and that the valve itself was worn on the lower side so that it lay in the valve chamber about as indicated by the dotted lines. This resulted in the valve remaining open along the edge *A* about one-sixteenth of an inch at all points of the stroke with the governor blocked out. This is why the engine speeded up and would have run away, with probably disastrous results, if it had not been watched.

The trouble existed on the head-end valve only. An attempt was made to give the valve more lap by changing the length of the valve link. It could not be done, however, without seriously affecting the position of the crank-end valve. In other words, the only way to overcome the fault was to rebore the port and fit a new valve; this was done. As to the valve itself, the fact that one of the ports is high up on the side favors the development of the fault shown.

A discussion of the various ways in which the trouble could be overcome is not in place here. The point is that through wear the valve had developed a fault that might have resulted in a serious accident, but for the watchfulness of the engineer in charge. He did not know what the trouble was, but he knew that the engine was likely to run away and he had been compelled to check it on the throttle many times. If he had been away a few minutes at a critical time, nothing would have prevented an accident. The governor would probably have been wrecked and the trouble would have been laid to it.

This experience leads me to believe that the insurance inspectors ought to examine the valve settings of engines, as well as satisfy themselves of the strength of the flywheel. It would not do to take indicator cards for conclusive evidence that the valves were all right, either. This particular fault would not have been shown in that way. The only right way is to block the governor out and watch the valves while the engine is pulled through a complete revolution.

Many engineers would discover the fault themselves, but here the engine was in the hands of a man who had not had the experience that would enable him to find the trouble. He is a capable operator in other ways, but has never known how to test the setting this way to find if the valves would do their part in the control of the speed. There are other engineers like this one in charge of plants, and it is a question whether this one would have been entirely to blame if an accident had occurred.

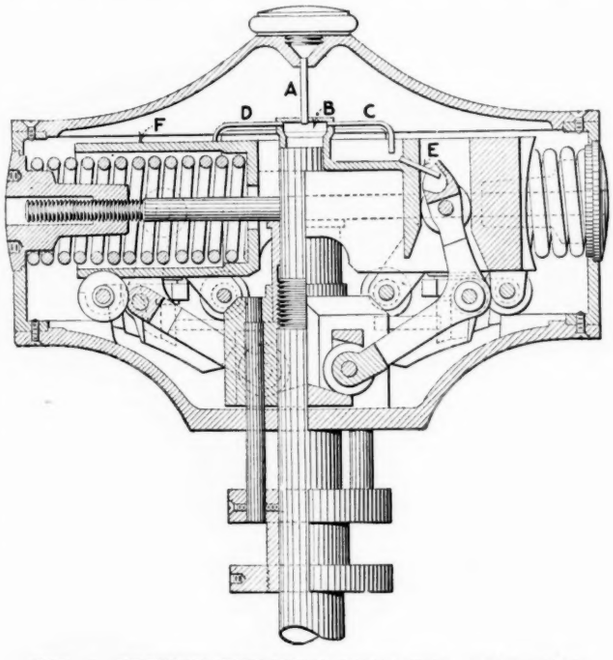


FIG. 2. SECTION THROUGH INVERTED GOVERNOR

The second experience was with the governor of a De Laval turbine, shown in Fig. 2. The experience may be of interest to the builders as well as to engineers.

This is a vertical-shaft governor which is oiled through a hole in the cap on top. The oil passes through the pipe *A* to the reservoir *B*. From there it passes by centrifugal force through the pipes *C* and *D* and into other reservoirs, one on each side. From these it passes through holes such as shown at *E* and thus reaches the parts to be oiled. The overflow from the casing oils the vertical spindle. The overflow is placed so that the level

of the oil does not reach the governor weights, one of which is shown at *F*. These weights are moved toward the casing by centrifugal force and are resisted by the springs back of them.

A 1,000-kw. unit controlled by the governor in question ran away one day for no apparent reason. The load was even and amounted to 80 per cent rating. The machine was shut down at once, and while it was coming to rest the engineer noticed that oil was running out of the casing in large quantities. He had that day set up a sight-feed cup over the governor casing to oil it automatically.

The conclusion was reached that too much oil had been fed into the casing, or that it had not passed through the overflow fast enough and had filled up the spaces and that the casing was full of oil up to and back of the governor weights. When running at full speed, the centrifugal force would place the oil back of the weights in a mass solid enough to interfere with the action of the governor, giving the effect of less weight and causing the machine to speed up. This was what had happened, and as soon as the oil was cleaned out the turbine was started again and gave no further trouble.

Had this turbine been wrecked, there would have been no evidence of governor trouble. As soon as anyone could have reached the wreck to investigate, the oil would have run out of the casing, leaving the governor in perfect shape unless injured by the accident. Had the governor been wrecked, it would have received the full blame.

These two occurrences show the need of investigating more than surface indications for the cause of trouble that will lead to serious accidents with a verdict of "cause unknown."

Bearing-Design Constants--I

By Louis Illmer

SYNOPSIS— This critique of friction literature compares the results ascertained by scientific inquiry with those found in machinery, operating under conditions of commercial service. Available friction data have been carefully digested with a view of eliminating discrepancies, but many of the experimental data lacked consistency, therefore only the relatively few that seem to accord with the coefficients generally employed for design purposes are used.

In references for friction determinations there is considerable variation in the values given for the coefficient of friction for presumably identical conditions. This coefficient is dependent upon a series of factors, and some of the inconsistencies occur because all of the controlling factors have not been taken into account. It therefore becomes necessary to pick out portions of data from different investigators and to patch these together, to arrive at a composite result that will be useful.

A determination of the coefficient of friction comprises the following factors: (A) Quality of the oil used, especially its viscosity characteristics; (B) quantity of oil supplied to the journal; (C) full constructive details, character of rubbing surfaces, and radiating capacity of the bearing; (D) accurate data regarding pressure, temperature and velocity factors (only one of these factors should be varied at a time).

Item A—Viscosity of the Oil

While the coefficient of friction μ is dependent in some degree upon the viscosity of the oil, yet this exceedingly complex relation could not be found with any degree of certainty from the data available, partly because authorities by no means agree upon the variation in viscosity to be expected with temperature change. Results of experiments indicate that viscosity, as measured through an orifice, cannot be considered scientifically accurate.

It is clear, that heavy pressures require a viscous oil that may be expected to have a relatively high coefficient of friction, and that lighter oils prove more suitable for low-pressure bearings. One reason determinations for the friction coefficient do not more nearly conform with the constants used in bearing design is that one grade of oil is used throughout a wide pressure range, while in commercial operation the oil would be graded according to the pressure.

Item B—Quantity of Oil Supply

While the importance of this matter has been quite generally recognized, most of the investigators fail to specify the rate of oil supply used in their friction determinations.

The vital necessity of a copious and evenly distributed oil supply to attain the minimum of friction is brought out in tests by W. F. Parish[1] on a 6x8-in. journal running at about 315 ft. per min. The characteristic results, Fig. 1, show that a stinted oil supply is accompanied by a considerable increase in friction, so that this important factor must not be lost sight of in comparing friction data.

The most satisfactory determination of the oil-supply requirements, the writer finds, is the surface lubricated per gallon of oil, a constant that may be termed "a rate of oil feed." Fig. 1 shows that one-tenth of a pint of oil, corresponding to about 1,000,000 sq.ft. of journal surface per gallon, would represent the minimum allowable and that about three times this rate of feed would produce the minimum friction.

One of the earliest experimenters to take into account the rate of oil feed was A. H. Van Cleve[2] in a test made on a 6x7-in. locomotive-axle bearing running at about 200 ft. per min. The oil feed was set to maintain a constant bearing temperature of about 97 degrees F., while the pressure varied from 25 to 200 lb. per sq.in. of projected area. Using different kinds of lubricants the oil required to meet this condition was practically constant, corresponding to approximately 300,000 sq.ft. of surface per gallon of oil.

[1] "Developments in Lubrication," etc.; National Association of Cotton Manufacturers, Oct. 2, 1913.

[2] "Tests on the Relative Value of Lubricating Oils"; "Scientific American," Dec. 9, 1871.

The writer has found that the rate of feed on engine bearings operating in commercial service, as set by different engine attendants, varied from 250,000 to 500,000 sq.ft. of journal surface per gallon of oil. These figures apply to oil-cup-feed lubrication, in which about two-thirds of the oil used may be caught up and returned to the filter. As indicated by Fig. 1, the average rate of about 350,000 sq.ft. of surface per gallon of oil is ample to insure the minimum friction loss in engine bearings, and any excess oil beyond this limit serves principally as a cooling medium.

Some friction investigators specify the rate of oil feed in drops, but this is unsatisfactory, even when the data given are sufficiently complete to permit a check. The most liberal rate of oil feed hardly exceeds 1,000,000 sq.ft. per gal., and in the majority of cases the supply was found to be much more stinted.

No doubt the use of a restricted oil supply accounts for much of the erratic friction data found in print. The judgment of an intelligent engine attendant affords a reliable guide, and he may be depended on to operate on a scientific basis intuitively.

According to Lasche[3], a well-designed ring oiler insures an ample supply of lubricant, the rate of feed being about 50,000 sq.ft. of surface per gallon. While all

μ = Coefficient of friction;

P = Pressure on the bearing per square inch of projected area;

V = Surface or rubbing velocity of the journal in feet per minute.

The value of H_o tends to increase with the factor t_h, but for the usual range of bearing temperatures it may, without serious error, be assumed to remain constant.

Lasche found the value of H_o for comparatively light outboard or generator bearings, without ring-oiler pockets, to be approximately 3 ft.-lb., per min. per sq.in. of projected area, while for more massive bearings with a large ring-oiler pocket, the radiation is increased to approximately 6 ft.-lb. and a well ventilated or air-cooled bearing such as a crankpin box will radiate about twice as much heat as in still air.

In data by Thomas for babbitted lineshaft-hanger bearings, H_o proved to be a little more than 2 ft.-lb. per min. The isolated condition of the pin-mounted bearing shell no doubt accounts for its low radiating power.

Working back from the temperature rise that occurs in commercial engines, the writer finds that for heavy-duty main bearings the radiating constant H_o must be equal to at least 6 ft.-lb. per min., and for outboard bearings,

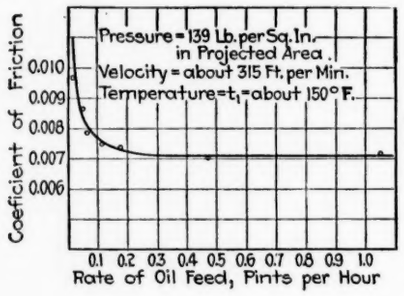

Coefficient of Friction
Pressure = 139 Lb. per Sq. In. in Projected Area
Velocity = about 315 Ft. per Min.
Temperature = t_1 = about 150° F.
0.010
0.009
0.008
0.007
0.006
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
Rate of Oil Feed, Pints per Hour

FIG. 1. INFLUENCE OF OIL SUPPLY ON FRICTION

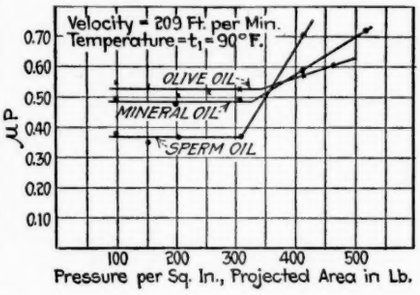


FIG. 2. PRESSURE BY COEFFICIENT OF FRICTION, AT CONSTANT SPEED

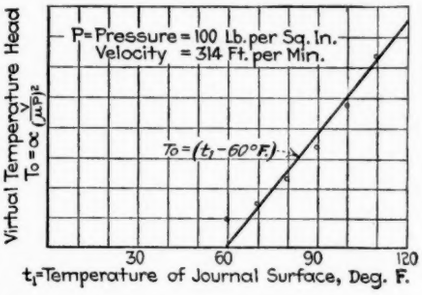

P = Pressure = 100 Lb. per Sq. In.
Velocity = 314 Ft. per Min.
Virtual Temperature Head
$T_o = \propto \frac{V}{(\mu P)^2}$
$T_o = (t_1 - 60° F.)$
30 60 90 120
t_1 = Temperature of Journal Surface, Deg. F.

FIG. 3. RELATION OF TEMPERATURES WITH VELOCITY AND PRESSURE CONSTANT

of this oil may not be carried under the journal, the generous supply no doubt accounts for the consistent results generally attained by this type of bearing.

Item C—Radiating Capacity of Journal

The radiating capacity of the journal may vary within wide limits, and is dependent upon the temperature head and such other factors as massiveness and the provision for conducting away the friction heat.

The radiating capacity of a journal may be conveniently checked by means of the following equation,

$$H_o t_h = \mu P V \qquad (1)$$

where

H_o = Specific radiating capacity in ft.-lb.; of the bearing per square inch of projected area per min. at 1 deg. F. temp. head.

$t_h = t_1 - t_o$ = Temperature head of the rubbing surfaces in deg. F., being equal to the surface temperature (t_1) minus that of the cooling medium (t_o) that is the atmosphere in case of naturally cooled bearings;

such as are commonly used for heavy-duty generator engines between 4 and 5 ft.-lb. In small ring-oiler motor bearings H_o is approximately 4 ft.-lb. The meager data available show that for natural radiation the constant H_o ranges between 2 and 6 ft.-lb. per min. per sq.in. of projected area, depending upon the type and constructive details of the bearing.

As regards temperature limits, 50 deg. F. represents a fair allowance for the temperature rise (t_h) in heavy-duty engine bearings under heavy pressure, while in high-speed bearings under light pressures, the temperature rise may be 75 deg. F. above an atmospheric temperature of (t_o) about 90 deg. F.

At a 50-deg. rise the total radiating power of a main bearing at H_o = 6 ft.-lb. will be about 300 ft.-lb. per sq.in. of projected area, which is about the same as that of a substantially built ring-oiler high-speed bearing at H_o = 4 ft.-lb. and a 75-deg. rise. These are about the limiting values permissible for natural radiation into the atmosphere, but by means of artificial cooling it is possible further to increase the bearing radiation, and in case of watercooling the heat offtake may be carried to about four times the value specified for natural radiation in the forging.

[3] "Zeitschrift Vereins Deutscher Ingenieure," Dec. 13, 1902.

A flushed supply of cool oil serves to keep the temperature down, but for oil set at a rate of about 300,000 sq.ft. of surface per gallon, the cooling effect is negligible, being less than 10 per cent. of the radiating power of a heavy-duty main bearing.

Item D—Coefficient of Friction

When bearing surfaces have been worn to a reasonably perfect fit, the coefficient of friction becomes a function of the temperature attained by the bearing, which in turn is dependent upon its radiating capacity. Hence, in checking friction tests it is important to know the temperature of the rubbing surfaces, also the temperature head with respect to the atmosphere and the degree of artificial cooling, if any. Pressure and velocity are the other factors that serve to fix the coefficient μ.

Subjecting the available data to critical examination, it is found that the Tower[4] and Lasche tests in some respects present the most satisfactory friction data, especially for pressures exceeding 100 lb. per sq.in. of projected area. Tower's series of tests were made upon a 3x6-in. steel journal, using various grades of oil artificially maintained at a temperature of 90 deg. F. The following equation is deduced from the average values,

$$\mu = C_1 \frac{\sqrt{V}}{P} \qquad (2)$$

where

$C_1 = 0.037$ for olive- and lard-oil bath;
$= 0.035$ for mineral-oil bath;
$= 0.027$ for sperm-oil bath;
$= 0.055$ for mineral-grease bath.

The pressure range for the equation is 100 to 500 lb. per sq.in. of projected area at a velocity variation of 100 to 450 ft. per min.

The values of the product $P\mu$, as found for a velocity of 209 ft. per min., are plotted in Fig. 2, which shows the constancy of this relation up to a certain critical pressure, after which it undergoes a decided increase.

The Tower data for lard oil and the change in the coefficient μ with temperature may be embodied in an equation having the following general form, which appears to apply also to the results ascertained by other investigators:

$$\mu = \frac{C_2}{\sqrt{T_o}} \qquad (3)$$

where

C_2 = A constant;
$T_o = t_1 - 60$ deg. F. = Virtual temperature head of the oil.

The factor T_o apparently bears some relation to the law of viscosity for engine oils, whose change with temperature may be likewise approximated by the reciprocal function T_o^n, where the exponent "n" usually lies between the limits ¼ and ½, its value depending largely upon the character of the lubricant used.

Fig. 3 represents the relation of the temperatures T_o and t_1, as deduced from Tower's data for lard oil, and is intended to show the degree with which the basic value of $T_o = t - 60$ deg. F. applies to this test. While the actual law of variation of friction appears to be somewhat more involved than is indicated by equation (3), the agreement at higher bearing temperatures is sufficiently close for present purposes.

Combining equations (2) and (3), the final value of the coefficient of friction, as derived from Tower's experiments, is represented by the equation

$$\text{(Tower)} \qquad \mu = \frac{1}{5P}\sqrt{\frac{V}{T_o}} \qquad (4)$$

The constant ⅕ applies to all of the lubricants experimented with, except sperm and rape-seed oil. The present concern is the friction of mineral engine oils, the heavier and more usual grades of which are covered by the foregoing equation.

Lasche's final equation for the friction coefficient applies particularly to a 4⅜x9⅝-in. steel journal running in a babbitt-lined ring-oiler shell,

$$\mu = \frac{2}{Pt_1}, \text{ in French units} \qquad (5)$$

$$\mu = \frac{51}{P\,(t_1 - 32°)}, \text{ in English units} \qquad (5A)$$

This equation is intended to apply within the pressure limits of 15 and 225 lb. per sq.in. and a temperature range of $t_1 = 85$ to 210 deg. F., while the velocity limit is given as 3,500 ft. per min.

An equation having the following form is approximately equally accurate:

$$\text{(Lasche)} \qquad \mu = \frac{4.5}{P\sqrt{T_o}} \qquad (6)$$

It will be seen that this equation is identical in form with equation (4), representing Tower's data, except that the velocity factor is absent. Equating these values the coefficient μ becomes equal at a velocity of about 500 ft. per min. Hence the discrepancy referred to may be eliminated by using the Tower formula below $V = 500$ ft. per min. and that of Lasche for greater velocities, all of which is consistent with the range given for the experimental data.

Further proof that the coefficient μ is practically independent of velocity above 500 ft. per min. is furnished by some high-speed experiments made on a Thurston friction machine by D. S. Woods and D. P. Carter[5]. The results of the test are plotted in Fig. 4, and since the radiation factor $P\ V \div T_o$ is found to be fairly constant this indicates that the coefficient of friction is independent of the velocity factor. The artificial cooling of the bearing accounts for the relatively high specific radiation, which is about four times that in a naturally cooled machine.

As regards the Tower and Lasche tests, both were made with engine oil having sufficient body to withstand heavy loads and for pressures above 100 lb. per sq.in. The results check quite well with those expected for a heavy-duty outboard engine bearing.

At lower pressures ranging from 10 to 50 lb., such as are commonly used in high-speed bearings, the values of the friction coefficient given by equation (6) appear to be about 1½ to 2 times larger than found in practice. One reason for this difference is the fact that in practical operation such bearings would be supplied with a relatively light oil.

[4]British Institute of Mechanical Engineers, 1884. See also Thurston's "Friction and Lost Work in Machinery and Mill Work," which gives a rather complete synopsis of these tests.

[5]Sibley College Thesis Tests, 1904.

The viscosity of heavy mineral oil at 130 deg. F. is approximately 1¼ to 1⅓ times that of a relatively thin oil measured at 165 deg. F., but this small difference hardly accounts for the considerable excess in Lasche's values for the coefficient μ at light pressures. At present the laws of viscosity do not appear to be sufficiently understood to make possible the modification of equation (6) so as to allow for such differences in oil body.

It also is reasonable to suppose that when the laws of friction are more fully developed they will show a certain continuity of change for the coefficient μ between light and heavy pressures. This is corroborated by a comparison of the foregoing experiments with those made by Thomas and others[6].

The experiments referred to relate to babbitt-lined hanger bearings running at relatively light pressures. Plotting these data, the following formula was derived as being fairly representative of these experiments:

$$\mu = 0.05 \frac{1}{\sqrt{P}} \times \frac{\sqrt[3]{V}}{\sqrt{T_o}} \qquad (7)$$

The tests were conducted within a velocity range of 100 to 300 ft. per min. and a pressure range of 33 to 100 lb. per sq.in. of projected area. The data were found to follow quite closely the $\sqrt{P}$ factor of the equation, while the temperature relation was less sharply defined. In view of the small temperature range experimented with, it is thought best to fix upon the factor $\sqrt{T_o}$, because of the evidence adduced by previous investigators.

Comparing the foregoing with equations (4) and (6), as based respectively upon the Tower and Lasche investigations, it will be seen that the essential difference lies in the pressure factor, the effect of which is to reduce the coefficient μ of equation (7) at lighter pressures below that given by the two preceding equations and assuming approximately equal values for the heavier pressures.

The friction coefficient is likewise found to vary inversely with the $\sqrt{P}$ in Woodbury's[7] experiments, as made upon light paraffin oil running at a velocity of 300 ft. per min., this proportionality holding true especially within the pressure limits of 10 to 40 lb. per sq.in. and 70 to 100 deg. F., a range commonly used in high-speed bearing design.

This is further substantiated by Hirn's friction experiments. Thurston[8], in discussing these data, states that his own experiments confirm the conclusion of Hirn that the coefficient μ may be expected to vary inversely as the square root of the pressure.

In any event, the pressure function may be expected to lie between the limits $\frac{1}{P}$ and $\frac{1}{\sqrt{P}}$, and since the latter appears to be in closer agreement with results attained in practice, it will be used as a basis for the design constants that are to follow.

In engine work the minimum velocity is usually in excess of 200 ft. per min., and it is safe to assume that the velocity factor in equation (7) will practically disappear at the previously determined limit of about 500 ft. per min. In practice, the relatively small difference in the value of the coefficient that should accrue at the slower bearing speeds seems to be lost in the less perfect manner in which the oil film is maintained. Hence for the purpose of deriving bearing constants by eliminating the velocity factor in equation (7) by inserting the critical value $V = 500$ ft. per min., the Thomas formula may be simplified thus:

$$\text{(Thomas)} \qquad \mu = \frac{2}{5\sqrt{PT_o}} \qquad (8)$$

The value of the friction coefficient as given by this equation is intended to apply particularly to bearings lined with babbitt metal and generously lubricated with a suitable mineral engine oil. That this equation holds good far beyond the limits of the experimental data from which it is derived becomes evident by comparing the plotted equation (8) with the Lasche equation (6), as shown in Fig. 5, each taken on the basis of high-speed

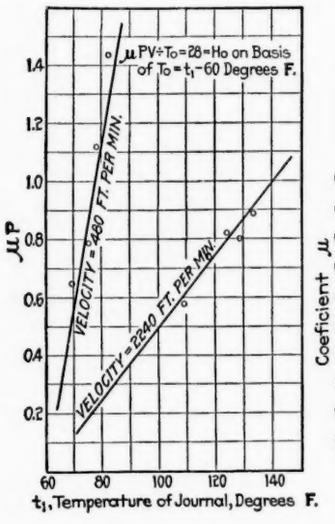


FIG. 4. COEFFICIENT OF FRICTION INDEPENDENT OF VELOCITY

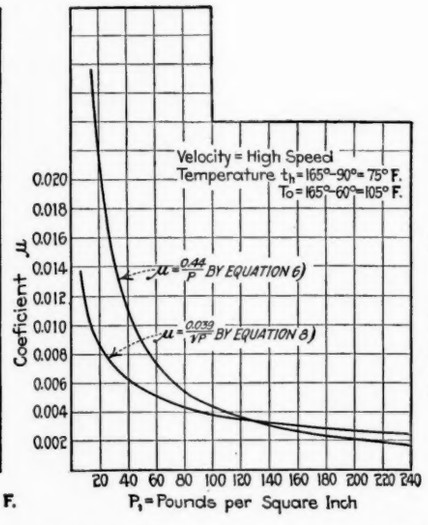


FIG. 5. COEFFICIENT OF FRICTION DETERMINED BY EQUATIONS 6 AND 8

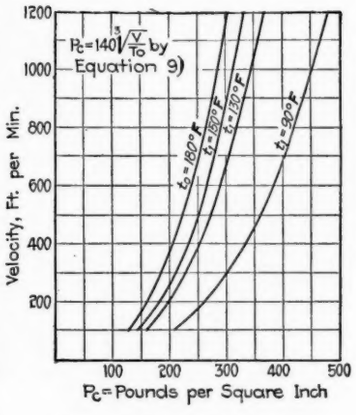


FIG. 6. CRITICAL PRESSURES DERIVED FROM EQUATION 9

[6]"Comparative Tests of Lineshaft Bearings," Carl C. Thomas, E. R. Maurer and L. E. A. Kelso; "Journal A. S. M. E.," March, 1914.

[7]"Trans A. S. M. E.," Vol. VI, 1884.

[8]"Friction and Lost Work in Machinery and Mill Work"; 7th Ed.

bearing conditions running at an assumed temperature head $t_h = 75$ deg. F. with respect to an atmospheric temperature of $t_o = 90$ deg. F.

Attention is directed to the fact that at lower pressures the Thomas values for the coefficient μ remain far below those given by Lasche and that the relatively small excess values for pressures beyond 125 lb. per sq.in. appear to be in better accord with the requirements of satisfactory bearing constants. Therefore equation (8) may be taken as representative of the coefficient of friction that may be expected in the practical operation of well-designed bearings, such as are generally used for engines, generators, turbines and like machinery. The older assumptions as to the probable coefficient of friction seem to be far in excess of actual values attained in modern practice.

It may be observed that most tests made on Thurston's friction machine are irregular and generally less satisfactory than tests made on bearings loaded on one side only. A large part of the data given by Thurston has been carefully considered, but the results of this analysis were not such as to be of use in the present investigation.

Excessive friction is also apparent in the results given by Parish (Fig. 1), made on a friction machine of this same general type and showing coefficients about two to three times as large as would be expected from equation (8).

This discrepancy may possibly be explained by the fact that when a journal is loaded only on one of its sides, the oil pressure is capable of lifting the shaft and thus provides the necessary clearance required for the maintenance of a proper oil film, while in the Thurston machine the balanced pressure effect evidently upsets the conditions essential for the establishment of such an oil film.

Taking Thurston's sperm-oil friction determinations, which show much more consistency than those for mineral oil, the values of the coefficient μ at heavier pressures are at least twice as high as would be expected from any of the foregoing equations. In fact, the results attained appear to correspond more nearly to friction occurring in crankpin bearings than to that of an outboard engine bearing.

Determination of Critical Pressure

As regards the breaking down of the oil film with increased pressures, this is apparent in Fig. 2, which shows that the Tower values for the product μP experience a rather abrupt increase whenever the friction factors exceed certain critical values.

This is a matter that has been investigated to some extent by H. F. Moore[9], who measured the electrical resistance between the journal and shell and thus found it possible to detect the point of breakdown in the oil film. The pressure was varied within the rather narrow limits of 10 to 80 lb. per sq.in. of projected area, for which the oil film was readily maintained when the journal clearance was not less than 0.003 in., a minimum limit that checks with the values given by Lasche. The establishment of the oil film is dependent upon the rubbing velocity of the journal, Moore giving the critical pressure at $P_c = 7.5 \sqrt{V}$. For the higher pressures, however, the writer finds that $P_c = 16.5 \sqrt[3]{V}$ to be in even better agreement with the original data.

Working backward from Tower's data, by finding the point of change in μP at a temperature $t_1 = 90$ deg. F., the critical relation is fairly well expressed by $P_c = 50 \sqrt[3]{V}$, a value approximately three times that previously given. Some recent tests made by the University of Wisconsin[10] on carefully ground journals show a carrying power of two or three times that found in Moore's earlier tests, and this result is more in keeping with the values derived from Tower's data.

The perfection of the journal fit is an important factor in friction determinations, and in this respect babbitt bearings have an advantage over bronze. The critical pressure must also be dependent in some measure upon the viscosity of the oil, but as yet no satisfactory data are available to show the variation of critical pressure with temperature. The conclusion based upon Thurston's and other friction data is that the following relation for critical pressure as applied to average mineral engine oil will serve present purposes,

$$P_c = 140 \sqrt[3]{\frac{V}{T_o}} \qquad (9)$$

This equation is plotted in Fig. 6 for the usual range of bearing temperatures, and with this as a basis, it is possible to further analyze Tower's data for variation in the coefficient μ when the actual pressure P is in excess of the critical pressure P_c. For mineral oil, it is found that the coefficient μ_{exc} for such intermediate friction increases approximately as $\sqrt{P \div P_c}$, which applies within the limits $P = P_c$ to $\frac{3}{2} P_c$.

Assuming that this same relation holds good for equation (8) as derived from the Thomas' data, the result would be

$$\mu_{exc} = \frac{2}{5 \sqrt{P_c T_o}} \qquad (10)$$

In that case the coefficient μ_{exc} may be expected to remain constant between the limits $P = P_c$ to $\frac{3}{2} P_c$. The experimental evidence on this point lacks consistency, some tests showing a rise in the coefficient μ_{exc}, while Tower's experiments indicate a further drop with increased pressure. On the basis of the limited data available, the consistency of the coefficient μ_{exc} is probable, especially so since Tower's values fall below the minimum values that may be expected in practice. According to equation (10), the coefficient μ_{exc} at $t_1 = 130$ deg. F. would be about 0.0025 for $V = 500$ ft. per min., a reasonably consistent result, since it is doubtful whether the coefficient μ_{exc} ever drops much below this value in commercial work.

[9] Sibley College Thesis Test, 1903.

[10] "Discussion on Lubrication of Journal Bearings"; "Journal A. S. M. E.," September, 1915.

Disastrous Boiler Accident in Buffalo—Fifteen people were killed and several seriously injured by the explosion of a boiler in the plant of the Kelker Blower Co., Buffalo, N. Y., Jan. 24, 1916. The three-story building was wrecked, burying the victims in the ruins, which caught fire. Further details will be given when the investigation discloses the probable cause.

To Build Diesel Engines—It has been announced that both the Newport News Shipbuilding Co. and the New York Shipbuilding Co. of Camden, have arranged to build under license the Werkspoor marine Diesel engine. This is a four-stroke-cycle design, the product of the Werkspoor Works, of Amsterdam, Holland, and is understood to have made a very good record in the ships in which it has been installed.

Loss Due to Combustible in Ash

By Reginald Trautschold

SYNOPSIS—Gives results of investigations of the American Gas and Electric Co. into the loss occasioned by combustible dropping through the grate into the ashpit.

Extensive experiments have been made by the American Gas and Electric Co. with the view of standardizing the efficiency of coal consumption in its plants and of estimating the possible savings if the best attainable efficiency were common to all plants. These experiments give valuable information on the effect of combustible

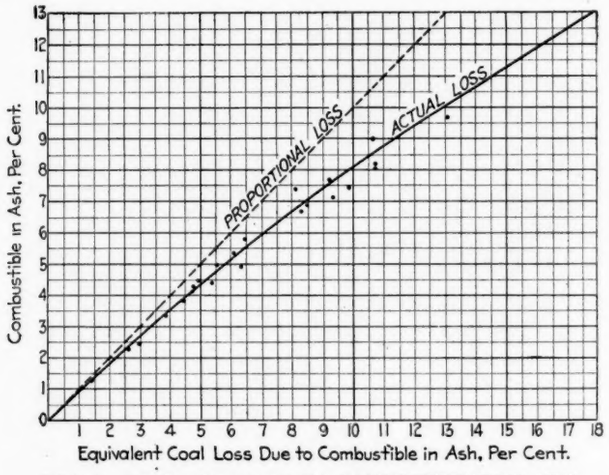


FIG. 1. COAL LOSS DUE TO COMBUSTIBLE IN ASH

in ash. Typical samples of ash from the plants in various parts of the country were carefully tested for combustible at the laboratory of the Scranton Electric Co., and the equivalent coal loss was calculated. Such tests were made over a period of several weeks; the plant in which the combustible in the ash was the lowest was taken as the desirable standard, and the possible yearly savings were estimated for the other plants. The estimated savings were the difference between the actual estimated yearly loss due to the combustible in the ash and that loss which would be entailed had all plants been as efficiently operated as the one taken as representing the desirable standard—the one in which the loss was least. Averaging the estimated savings of eight plants scattered over considerable territory, which may safely be taken as truly representing average conditions, gives the surprising total of $34,100 per year, an amount well worth considerable effort.

The data obtained by the experiments are given graphically in Fig. 1 and clearly indicate that the relationship between the combustible in ash and the equivalent coal loss due to combustible in ash closely conforms to that shown by the "Actual Loss" curve. The broken-line curve, "Proportional Loss," shows what would be the equivalent coal loss due to combustible in ash did this loss vary directly with the percentage of combustible in the ash, as is generally believed. The addition of this second curve to the chart forcibly draws attention to the marked increase in waste of fuel as the percentage of combustible in ash increases.

Fig. 2 presents the "law" of the "Actual Loss" curve in Fig. 1 in somewhat different manner and in a form by which the actual coal loss can be easily calculated for any percentage of combustible in ash.

The elimination of all combustible in ash is not yet possible, of course, but the percentage can and should be minimized. The best result attained in any of the plants of the American Gas and Electric Co. was in its Newark plant, in which the record for one week was but 1.29 per cent. of combustible in the ash. This record was not always obtained, but the poorest "desirable standard" reported in the data from which Fig. 1 was plotted was 3.38 per cent. at the Atlantic City plant for the week ending July 31, 1915. The poorest result reported during the experiments showed the presence of 12.43 per cent. combustible in the ash. Even this maximum waste is not at all an unusual condition in the average plant; 10 per cent. of combustible in the ash is about the average condition.

There is considerable difference between 10 per cent. combustible in the ash and the low record of 1.29 per cent. made at the Newark plant. The achievement of the American Gas and Electric Co. may not be attainable in the majority of plants without extensive and expensive improvements in their grates, etc., but it would appear possible to improve average results by the exercise of greater care in firing. A record of 5 per cent. combustible in ash should be easily and inexpensively attainable in most plants.

The coal loss (equivalent) due to the presence of 10 per cent. combustible in the ashes is 122.5 per cent. greater than that due to the presence of 5 per cent. With coal at $4 per ton, this means a waste of 28.6c. per ton,

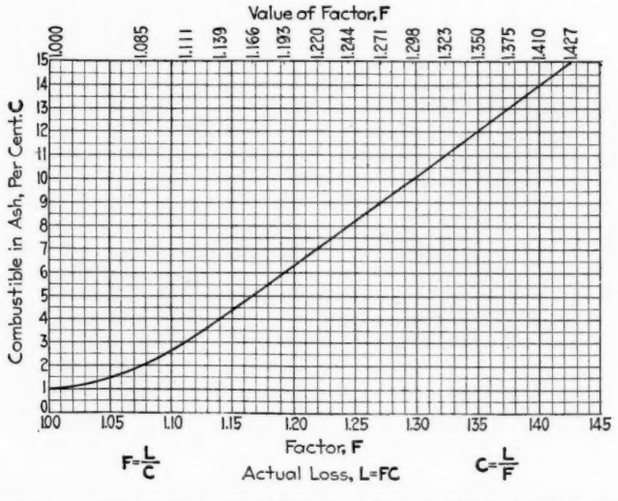


FIG. 2. CHART TO DETERMINE ACTUAL COAL LOSS FOR VARYING QUANTITIES OF COMBUSTIBLE

the 5 per cent. loss being taken as unavoidable. What this actually means is shown by an example: In a plant of 1,000 hp. operating 10 hours per day, 308 days per year, on coal commanding $4 per ton delivered to the grates, the yearly coal consumption would be about 3,500 tons—equivalent to 3½ tons per horsepower per year. Such a record would be attainable in a plant of this size

operating under good load conditions and efficient in most respects. Assuming that analyses showed 10 per cent. combustible in the ashes and that subsequent exercise of greater care enabled this loss to be reduced to 5 per cent. the net saving realized would amount to more than $1,800 per year. Example:

Conditions: Size of plant, 1,000 hp.; fuel consumption, 3,500 tons per year; combustible in ash, 10 per cent.; net cost of coal, $4 per ton.

Required: Annual saving due to reduction of combustible in ash to 5 per cent.

The actual loss, L = FC, where F is factor from Fig. 2 and C is percentage of combustible in ash.

Ten per cent. combustible in ash entails coal loss of 12.98 per cent. (L = 1.298 × 10 = 12.98 per cent.), and 0.1298 × 3,500 = 454 tons per year. The net coal consumed for power = 3,500 — 454 = 3,046 tons per year.

Five per cent. combustible in ash entails coal loss of 5.83 per cent. (L = 1.166 × 5 = 5.83 per cent.). Actual coal required for power purposes, including loss due to 5 per cent. combustible in ash = 1.0583 × 3,046 = 3,224 tons.

Cost of coal (10 per cent. combustible in ash) 3,500 × 4	$14,000
Cost of coal (5 per cent. combustible in ash) 3,046 × 4	12,184
Net annual saving	$1,816

Slide Rule and Flow Computer

The slide rule shown in Fig. 1 should prove a time saver to members of the engineering profession. It can be used not only for all ordinary computations of multiplication, division, square root, etc., but in addition offers a direct solution for problems involving the flow of liquids and gases and the proper sizes of pipe for different conditions of flow. The rule is made of solid celluloid and is permanently attached to a leather case. Directions for its operation are printed on the inside of the cover. The rule has two slides which are reversible, one side being used for steam or water-flow problems, and the other side, which is printed in a different color, for problems dealing with gas or air.

As indicated on the face of the rule, each quantity involved in the figuring of problems dealing with the flow of liquid through pipes is assigned to a separate scale,

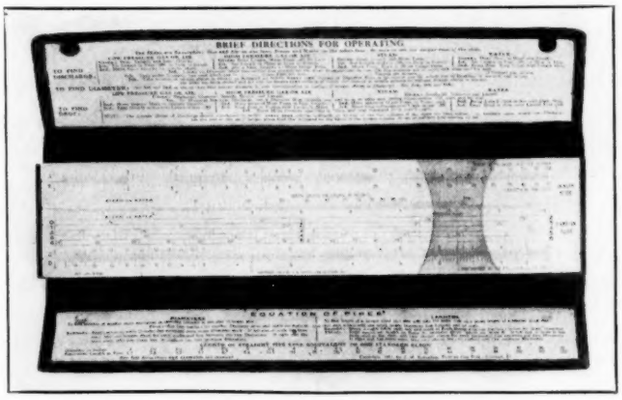


FIG. 1. THE RULE AND ITS OPEN CASE

and the answers are read directly from the scales. Consequently the solving of flow problems becomes a simple matter, and much time is saved over using the complicated formulas in standard use. To illustrate the operation of the rule the following problem is solved; notice that the rule is easily read:

Find the size of pipe necessary to pass 2,420 lb. of steam per minute; initial gage pressure, 150 lb.; final pressure, 140 lb.; mean pressure, 145 lb. (initial minus one-half drop); length of pipe, 1,230 ft.

Referring to Fig. 2, first set 12.3 (1,230 ft.) on the "length" slide opposite 10 on the "drop" scale. Second, set the "pressure mark" on the diameter slide opposite 145 on the "mean pressure" scale. Third, move the finder to 2,420 lb. on the "discharge" scale, and the answer is a 14-in. pipe.

In the middle heavy-type column on the diameter slide will be noticed numbers ranging from 1 to 5. In the pres-

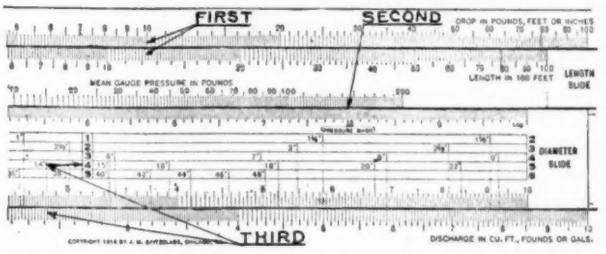


FIG. 2. THE RULE SET FOR A STEAM FLOW PROBLEM

ent problem the number 2,420 has four integer places, so that the size of pipe is read from the No. 4 scale. If there had been five integer places, or in other words, if the problem had been to pass 24,200 lb. of steam per minute under the same initial and final pressures, then the diameter of the pipe would have been read from the No. 5 scale and the answer would have been a 38-in. pipe.

The rule was designed by J. M. Spitzglass, of Chicago, and has recently been placed on the market by Gordon M. Proudfoot, 451 Peoples Gas Building, Chicago.

Noncondensable Gases in the Absorption Machine*

The experimental work on the subject of foreign gas formation in ammonia refrigerating systems undertaken by the Bureau of Standards is not sufficiently advanced to permit of even a preliminary survey of results at this time. However, it was thought that it might be of some interest to point out the lines of work now being followed and the possible needs of the problem, in order to provide definite and authoritative results. The two types of systems, absorption and compression, are being considered independently in relation to the problem as the conditions and factors involved are different. The results so far obtained have to do with the absorption system. While not conclusive or extensive in nature, they are sufficient to indicate the line of work to be followed.

During a recent overhauling and recharge of the Bureau absorption machine, outlets were provided through which it will be possible to take gas samples for analyses from various parts of the machines independently, thus enabling us to localize the place of formation, study the behavior of the gases in the system and the variations in its composition. Of considerable importance will be the study of the actual quantity of gas formed, and its effects on operating conditions. To do this, it will be necessary to operate under a load as constant as can be maintained. Preliminary experiments at the Terminal Power Co.'s plant in Washington, D. C., with this object in view, were made during July. The results obtained were only qualitative in character, owing to the variation in load

*From the report of the committee to determine the sources of foreign gases in refrigerating systems, American Society of Refrigerating Engineers. Contributed by E. P. McKelvy, of the Bureau of Standards, Washington, D. C.

at the plant. During this month 1.5 cu.ft. of foreign gas, mixed with 14.3 lb. (302 cu.ft.) of ammonia was removed from an 80-ton machine. The average composition by volume of the gas blown off was about 0.5 per cent. foreign gas, the remainder being ammonia.

Here it is evident that purging was unnecessary. From a 50-ton machine at the same plant, 3.3 cu.ft. of foreign gas mixed with 2.5 lb. (53 cu.ft.) of ammonia was removed, thus the average composition by volume of the gas blown off was 6.2 per cent. foreign gas, the remainder being ammonia.

At the Bureau plant it is hoped to be able to definitely determine the relation between operating conditions and gas formation, as well as the effect of purging on operating conditions. An apparatus has been built in which it is hoped to study the formation of foreign gas on a small scale. The conditions in an absorption plant will be imitated as closely as possible, and more particularly the effect of impurities in the ammonia will be studied.

The use of various brands of ammonia is also contemplated. It will be possible to closely control the various factors. To throw light on the behavior of foreign gas in the system, a study of the solubility of the component gases in liquid ammonia at various temperatures and pressures is to be made. In connection with this problem, analyses have been made of the gases that frequently occur in hot-water heating systems. Their composition shows a surprising similarity to the composition of the foreign gas usually found in an absorption refrigeration system.

Relative to the paper by Prof. R. Planck[1] Mr. McKelvy stated as follows: Several important considerations have been overlooked in the author's consideration of the subject. For example, the possible influence of moisture introduced into the system; of other impurities in the ammonia; and the relation of the oil always present to the gas formed.

The author's theoretical considerations demand that the composition of the gas formed be 75 per cent. hydrogen and 25 per cent. nitrogen by volume. As a matter of fact, in gases that have been analyzed, the nitrogen generally exists in a much higher percentage. While some of this loss of hydrogen may possibly be due to faster leakage, probably other factors are at work in causing gas formation. In one analysis, however, the amount of hydrogen was much greater than it should be if there was a straight decomposition of ammonia. Professor Planck's paper emphasizes the need of a careful experimental study of the problem such as is under way at the Bureau of Standards.

[The importance of further investigation of this subject to the refrigeration industry is deeply appreciated, as was shown by the fact that inasmuch as the Bureau of Standards needs a small compression machine to continue experiments, President Doelling of the society, also president of the De La Vergne Machine Co., New York City, agreed to furnish the half-ton compressor; Theodore O. Vilter, of Milwaukee, agreed to supply the condenser and receiver; while Henry Torrance, of the Carbondale Machine Co., agreed to furnish the expansion piping and valve. The motor will be given by J. F. Lewis, of Cincinnati, Ohio.—Editor.]

[1]July "Journal American Society of Refrigerating Engineers," and "Power," Dec. 28, 1915.

JUST FOR FUN

Shut Down Two Hours Early

I was putting up for a short time in a city of about 4,000 in the Southwest. The town had electric lights, but they were available until 11 p.m. only. After that hour and in the early morning we had to use kerosene or candles. One night my lamp gradually died down at 9 o'clock. I "cussed" softly and lighted a candle. Everybody was busily engaged lighting something or other, for the town was prepared for the emergency. Nobody seemed disturbed besides myself. I inquired as to what might be the matter, but no one would venture an opinion on the subject. "It ain't nothin' unusual," I was told.

So I strolled over to the power house to get my information first hand, and there I found the fireman just closing up, locking the door. "What's the matter?" I asked. "Nothin'." "Why did you shut down so early?" "Ran out of coal." "Why didn't you borrow some?" "'Twa'n't necessary. We're expectin' a care some time tomorrow."

Whereupon we went over to the nearest saloon and drank 'er down, thoroughly satisfied with things as they were.—S. F. Wilson, New York City.

This Thermometer Needs a Safety Valve

A traveling engineer on visiting one of his company's plants chanced to notice a thermometer attached to an open feed-water heater that showed 175 deg. F. He remarked to the engineer in charge that the thermometer showed too low a reading. The indignant reply was, "Why, no! She is carrying 175 lb. now, and any more pressure would burst her."—J. W. Dickson, Memphis, Tenn.

Evidently Not Much of an Engineer

The following, a clipping from the *Cleveland News*, is self-explanatory (?):

SERVE SAME PURPOSE

"These reserve banks serve the same purpose as the governor of a steam engine," said a Federal Reserve official. "If you revolve the governor as fast as it can go at all times, it loses its power to govern. But if you increase its motion when the engine slows down and decrease it when the engine accelerates, you have a device which gives the engine constant steadiness and consistency. The currency law is also an equalizer."

J. R. Belknap, Midland, Mich.

Is a Boiler a Stove?

A half-score years ago, while acting as assistant to a railroad pump-house foreman, I reached the pump house at noon and found it occupied by the section gang. Outside it was bitter cold—about forty below. Inside the pump house the section men were seated around the old vertical boiler making merry.

The boiler was right hot. Inside, the shell was red hot. But there wasn't an ounce of steam on. So there was absolutely no danger, as I had emptied the boiler clean on the previous trip, and left it empty. No damage was done, so far as I could see in using the boiler thereafter, and so my conscience has hurt me ever since for giving the poor fellows———. S. F. Wilson, New York City.

Editorials

The United States Government's Water-Power Report

The essential facts gleaned from the Government's investigation of water-power control are: First, that commercial central stations control nearly one-fourth of the total primary power in the United States and about half the present developed water power, their undeveloped holdings being eighty per cent. of the developed; second, that during the past three years water-power development has been three times as great as steam, with a marked over-development in the Western and Pacific Coast States, public-utility corporations in these states controlling ninety per cent. of all the power as compared with approximately sixty per cent. four years ago; third, that sixty-eight per cent. of the total central-station power in the United States is controlled by eighty-five corporations, of which six control one-fourth; finally, through a system of interlocking directorates many of these corporations are closely related.

The investigation shows a general trend toward concentration, but whether this constitutes a so-called water-power trust is of little import, so long as the people retain the upper hand. It is only when they relinquish this that big business becomes dangerous. Public-utility business is essentially monopolistic, and large developments can be carried out successfully only by big interests. Moreover, it is but natural from the financial standpoint that such interests should seek to specialize in these projects.

Regulation by public-service commissions, while accomplishing much, is inadequate where hydro-electric power is concerned. To safeguard completely the public's interests it is essential that the Government retain its vested rights in the natural resources of the country, permitting and encouraging development by private capital and even protecting such investments; but only so long as the privileges are not abused.

The measures now before Congress, notably the Ferris bill, would accomplish this on terms extremely fair to private capital while at the same time protecting the public. In the fight that has been waged against this bill by the water-power interests, much has been made of the claim that the policy of the Federal Government is retarding development in the West. The recent investigation has shown this to be a mere subterfuge in an attempt to influence public opinion. It appears that there is actually an over-development in this section, and until a market is found for the excess power, additional development will not be attempted: although it is highly desirable from the corporative standpoint to get control for future development of as much potential water power as possible.

Although the investigation has disclosed nothing of a startling nature, it has served a useful purpose by placing the Government in possession of pertinent data and by throwing the spotlight on the invisible control of the hydro-electric interests, so that any attempts to influence legislation in the future must be more open.

Getting Together in New England

If you had tried five years ago to get such a crowd together as that that participated in the seventh annual banquet of the American Society of Mechanical Engineers, American Institute of Electrical Engineers and the Boston Society of Civil Engineers, held in the City Club, Boston, Tuesday evening, February eighth, you would have failed. The get-together spirit has gripped New England engineers as it never has before, and the dinner in Providence some weeks ago, when the committee was called upon to provide for many scores more people than it had anticipated, was the first notable manifestation.

Getting together socially cannot but mean much good professionally. The public and its officers know too little and in too vague a way what engineering is to social welfare. If this were not so, we would likely see them doing more of what Governor McCall, in his speech at the Boston banquet, said they might well do, namely, apply their skill and training to the administration of the communities' affairs.

A new era for engineers may have opened with the appointment of the Naval Advisory Board. Somehow tradition makes one expect to see New England be first to enter it.

Higher Steam Pressures

The recent discussion of higher steam pressures has brought out some facts that deserve attention. Steam pressures have been steadily increased ever since the introduction of the steam engine, and it seems unreasonable to assume that the pressures at present in use are the highest that it is advisable to produce in commercial work. Fuel costs and the endeavor to secure most efficient operation are now forcing steam users to give careful attention to all probable gains in economy, and the possibilities of greater efficiencies with higher steam pressures will therefore receive added attention.

It is reasonable to expect that some difficulty will be experienced at first in producing a satisfactory boiler for such pressures, and some decided modifications may be expected from the types at present in use. However, such a boiler will ultimately be developed as the demand increases, and it is satisfactory to note that earnest efforts are already being made along this line. Whatever the final form of these new boilers may be, it is more than likely that it will necessitate changes in our present standard power-plant designs.

The steam will leave these high-pressure boilers at higher temperatures than in present practice. It is not probable that the amount of heating surface per unit of evaporation will be greatly increased over present practice. It is therefore evident that the flue gases must leave at higher temperatures than are now usual, and hence there must be a proportionately greater loss up the chimney

unless some means is provided to recover this heat. Economizers will then be given increasing consideration with these higher pressures.

In the case of the Connor's Creek plant at Detroit, it was pointed out that the present-day forms of economizers with cast-iron tubes were not considered suitable for high steam pressures. In the subsequent discussion, it was pointed out that newer designs of economizers may be expected shortly, made of more satisfactory materials and of radically different designs. The use of boiler steel for the high temperature and high-pressure end and cast iron for a low-pressure stage, where lower temperatures invite trouble from corrosion, is a possibility. In such a case there would again need to be changes made in plant design and arrangement.

So far consideration has been given only to economizers to heat the feed water. Theoretically there are possibilities of gain by heating the air for combustion by means of the waste heat of the flue gases in air economizers. This would not be practicable in present furnace systems, for the upkeep from burnt-out grates would make such operation uneconomical. But if powdered coal were used, preheated air would be most desirable. If boilers can be built for utilizing the principles of surface combustion, then again the use of both preheated air and gas will be very desirable and even necessary for very high economy. It is therefore evident that under certain circumstances the hot air economizer, as well as the feed water economizer, may be installed in new high-pressure plants.

In discussing high steam pressures it was pointed out that there would be decided changes in the construction of steam piping, and solid welded piping was suggested. Such systems would need to be of better and heavier material than is used at present, and consequently they would be more expensive. The density of the steam would be greater, and hence the size of the pipes for a given output of plant would be smaller. But on the other hand, temperatures will be higher and heavier and better pipe insulation will be needed.

Valve manufacturers will be forced to produce a new line of double extra-heavy steel valves for the new service. Should these be straightway valves or globe valves? What materials should be used to form their seats? What form of packing should be used on their stems? These new problems will have to be met and solved before the high pressures can be utilized.

At the same time other steam specialties will have to be redesigned for the new conditions. Traps, separators, feed-water regulators, pump governors, etc., will need modifications either in strength or in the construction of certain details.

It has been pointed out in recent papers and discussion in *Power* that there is a practical limit to the temperature of superheated steam above which it is undesirable to go at present. Nevertheless, a better knowledge of materials will undoubtedly allow us to increase this upper limit to about eight hundred degrees Fahrenheit. If, however, it is not desirable to increase this steam temperature at the same time that pressures are increased, then it has been shown that the steam when used in a steam turbine will become wetter toward the end of expansion than is now the case with moderate pressures and high superheat.

This might not be an altogether undesirable condition if it were possible to separate this moisture out between the stages of a turbine. Unfortunately this has so far been impracticable, for no satisfactory separator has been produced for this service, largely on account of the high steam velocities. The wetness factor, moreover, increases most rapidly in the last few stages, where the pressure drops are small, the velocities high and the turbine-blade efficiency greatest. However, even this difficulty from moisture may be overcome in future designs.

There will be no sudden change to such higher steam pressures, and they will be adopted only as boilers, piping, fittings and engines or turbines are available for such purposes. It therefore lies largely with the manufacturers to develop their lines for such use and with engineers to become familiar with the materials and arrangements necessary under the changed conditions.

Wanted--An Engineer(?)

The following advertisement appeared recently in a Kansas City paper and a similar one—probably by the same employer—appeared about two months before:

ENGINEER—White, stationary, high-pressure; first-class Kansas City license; 9-hour shift, 2:30 p.m. to 11:30 p.m.; $65 per month; state your age, address, telephone number, whether married, union or nonunion, whether you have good Kansas City written references and your own tools; you will be required to do repair work about the building; you will also have a rope elevator to operate from 6 p.m. to 11:30 p.m. Address ——— ———.

There is a humorous as well as a pathetic side to this advertisement, which the man who paid for it probably fails to appreciate. He hardly wants an engineer, either white or black, and he certainly does not want him stationary if he does the repair work about the building from 2:30 to 6 p.m. and then furnishes human motive power for a "rope elevator" from 6 to 11:30 p.m.

He may want a "high-pressure" man, and besides that he must be high-speed, but why does he need to have a first-class Kansas City license to run a rope elevator, etc.?

The hours of labor are fair except in relation to the salary offered. Of course the applicant must be just the right age, neither too old nor too young, and he is supposed to have a telephone in his residence for the convenience of the advertiser. Telephones in Kansas City cost $3 per month and all $65-a-month men have them (?).

Probably the question whether married or not is to help figure how long it will be before he starves to death on the salary, and whether union or nonunion, to find out whether the advertiser is getting an engineer or a hod-carrier. The applicant must also have a set of tools for doing the repair work about the building, but this will consist only of a plumber's kit, an electrician's outfit for fixing the wiring and just a few engineer's tools, as there will not be much use for the latter—in all about $200 worth of tools.

Seriously, however, it is pathetic to think of a business man thus advertising for an engineer. Without doubt the plant has a boiler carrying high pressure, and lamentable things might happen while the engineer is fixing some plumbing or operating an elevator. The cost of one accident would pay the engineer a decent salary for life.

Such employers should be considered criminally ignorant if not negligent, and should anybody be injured in their building they should be prosecuted just the same as any other criminal. It is to be hoped that Kansas City engineers or employers of engineers are not to be judged by this advertisement.

Correspondence

From One Who Knew Mr. Hill

Reading the obituary of John A. Hill in *Power* of Feb. 1 brings to memory my first meeting with Mr. Hill on the Denver & Rio Grande R.R. many years ago, when I operated the shop engine at Pueblo, Colo. He was at that time fireman on a passenger locomotive—a handsome, clean-cut young man with a cheery word for everyone.

He was rated by his fellow workers as "white," which was the highest commendation given to any man in that part of this country at that time, be he millionaire or laborer.

When I saw him some months ago at the new building, he was the same John A. Hill that he was when I first met him, only more serious from years of work and responsibility.

If there is any reward in the unknown hereafter for those who are just and fair to their fellow-men on earth, John A. Hill is certainly entitled to the best that is to be given.

NATHANIEL B. SAWYER,
Chief Engineer.

295 Broadway, New York City.

Engineers' Reading Matter

The purposeful anecdote, "Why Joe Stays in the Rut," in the Dec. 7 issue, seems to me to present an exaggerated view of this problem. I have been up against the same proposition myself and have successfully pulled through it and have seen others do the same.

The great fault I find with most "Joes" is that they seem to think that a book on engineering, whether civil, mechanical or electrical, must be as clear and as interesting as a novel and be able to hold the reader's attention by sheer excitement of plots or otherwise.

On the contrary they are just the reverse, and many who pick up an engineer's book expect to find arithmetic, algebra, geometry, etc., together with interesting data and explanations all worked out to apply on the main text. This, of course, is impossible, and if the reader has not the knowledge of these preparatory subjects, he blames the author instead of getting books on these most-needed subjects.

I know a dynamo tender who at one time could not even multiply numbers of more than two figures, and this same man expected to get a complete knowledge of dynamos, motors and switchboards by buying and reading a set of four books on dynamos and switchboards, in which of course the author assumed that the reader had some knowledge of mathematics and materials. At that time I was taking a correspondence course, and I showed this fellow the folly of trying to learn engineering without mathematics and physics, so he took a course, and in three years he was able to calculate field and armature windings, kilowatt readings from volt and armature readings, horsepower from indicator cards, etc.

Men that are in "Joe's" class, if they live in a large city, should attend night school and get these things, and if in rural districts or small towns, a correspondence course is next best. Another trouble is that few men like "Joe" have the "stick-to-itiveness" to study nights after working hard all day, but once the habit is acquired, it is a pleasant way to spend some of the evenings of the week. They must remember that engineering is no sinecure and in fact is the hardest of all professions, which is easily proved by the fact that colleges and universities teaching engineering have the longest hours of study and the least amount of leisure time during their school year. Also studying, like anything else, should be done with some system, and regular hours or certain nights should be kept as far as possible for study only.

Utica, N. Y. H. G. BURRILL.

I was much interested in "Joe's" story in your issue of Dec. 7, 1915, and I cannot help offering a little advice, for I have known so many to be in the same position.

My advice to "Joe" is to let the books alone for a while (no this is not heresy, just common sense) and take to the magazines such as *Power* (this is not intended as a puff), *American Machinist* and others that talk to the engineer and machinist. Read, for example "Will Quizz, Jr." He gets above the average sometimes, but in the main he talks in the language "Joe" can understand. Then read the correspondence sections and Inquiries of General Interest. Last but not least, read the advertisements and send for catalogs of equipment of immediate interest. Do not attempt to jump into higher mathematics at once, but remember that we must all creep before we walk. Do this regularly and persistently and you will be surprised at the progress made, and before very long you will be delving into the deeper mysteries of mathematics.

It should be remembered that higher mathematics is only an extension of ordinary arithmetic, and when you learn a rule—such, for instance, that pressure times volume is always constant—remember that this rule applies to intricate calculations as well as the ordinary.

One of the hardest things I have had to teach prospective engineers was to have them remember that a rule is a rule and does not change with conditions, if $x = x$ today, it also equals x tomorrow.

Those who will take my advice will soon be able to pick out the books they want and understand them.

Washington, D. C. W. R. METZ.

What a Little Thought Will Do

I was discharged because I could not keep up the steam pressure. I worked hard, piled on the coal galore, stirred, sliced, hoed, raked, did everything conceivable to make the coal burn fast, but failed. I was a failure even though I did my best. And the worst of it was, I had been recommended by my former chief.

I stood looking at the new fireman employed to take my place—a man about twenty years my senior. He

was calmly smoking a corncob pipe as he worked. He kept going steadily, but I noticed that he did not even perspire. Ye Gods, how hard it had been for me!

"How do you do it?" I asked. "The boilers are overloaded. I told them yesterday that it couldn't be done."

"It's easy enough," said the new but experienced man, "when you know how. See how thin that fire is? The greater the load the thinner the fire; that's my rule, and it's a good one. To burn a lot of coal you need a lot of air, and the only way you can get it through the fuel bed is to keep the fire thin. When the load is less than at present, I make the bed thicker. If you want to try it again, here's the shovel. I'll teach you something."

Did I grab the shovel? Indeed I did, and the new man did not do much during the rest of that day except boss me, instruct me and "kid" me. I learned how to fire.

Next day I was reëmployed. The new man was called back to his former place at an increase in pay, and he recommended me as a fit successor.

I was never discharged again. S. F. Wilson.

New York City.

Wants Inspection in Oregon

I have been reading with interest about the recent proposals to have removable coverings for the joints of lap-seam boilers in Massachusetts.

It would be a blessing if we had some such law or a law requiring boiler inspection here in Oregon. Do the people of Oregon believe their lives are less valuable and their safety less important than the lives and safety of Massachusetts citizens? Guy Greenleaf.

Salem, Ore.

How Much CO_2 To Expect

In the article entitled "How Much CO_2 To Expect," in *Power*, Nov. 23, the attention of the reader is called to the fact that most of the tables showing CO_2 percentages and corresponding fuel losses are based on pure carbon as fuel and are only approximate when applied to other fuels.

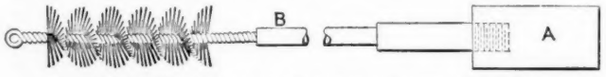
The author concludes his article with a curve showing the relation between excess air used and percentage of oxygen in the flue gas, which, he says, applies to all fuels. The curve given is plotted approximately from the equation, $Y = \frac{X}{20.9 - X}$, in which Y is excess air and X is the percentage of oxygen.

This curve is based on the assumption that all the oxygen actually used in combustion combines with other elements in such a way that the volume of the resulting gases is the same as was occupied by that portion of the oxygen in the air. This is the case when the products are CO_2 and SO_2, but, as Mr. Azbe states, when hydrogen is present in the fuel the product of its combination with oxygen is not a gas at room temperature. Consequently when flue gas from fuel containing hydrogen is referred to, this equation with its curve applies only approximately. When applied to fuel oil or natural gas, the error becomes quite noticeable. With CH_4 as fuel, oxygen = 10 per cent., the curve indicates 92 per cent. excess air while the correct figure is 83.3 per cent. If, with the same fuel, the CO_2 drops to 4 per cent., oxygen = 13.6 per cent., the figures from the curve would be 209 per cent. excess air, though the actual is 170 per cent. excess air. The curve has the advantage of its error being small with most fuels over the usual range. Approximate results are often useful, but it is well, especially for engineers, to know when results are only approximate. A misstatement of a theory or its application does not help dispel the many misunderstandings of the results from flue-gas analysis for various fuels.

Massillon, Ohio. A. T. Hutchins.

Cleaning Condenser Tubes

Surface condensers are regarded as the most efficient type for large turbine units, because the maximum vacuum can be obtained in them and the condensate used for feeding boilers. Cleaning the sediment from the inside of condenser tubes becomes necessary when the vacuum falls slightly, for the efficiency of the unit is then seriously affected. This is "some job," as the condenser of a 15,000-kv.-a. turbo-generator has about 5,200 one-inch tubes about 16 ft. long. Cleaning these tubes has been



NEAT-FITTING PLUNGER ON BRUSH HANDLE

done in a large power house in 18 hours by three men, using the following method:

One-hundred brushes were procured and to their shanks B pistons A were attached, fitting freely in the condenser tubes. Only the small doors were removed from the water boxes, and a man went inside and inserted the brushes in the tubes. They were then forced through to the other end by hydraulic pressure, brought back, and the operation repeated until all tubes were cleaned and the job completed. The water was kept under 100-lb. pressure and supplied through a flexible hose having a quick-opening valve and a cone-shaped nozzle.

Brooklyn, N. Y. Frank W. Wearin.

Nearsighted Operation

Two 2,000- and two 1,000-kw. turbines comprised the generating sets; surface condensers were installed in the basement. The circulating water was taken from the river about one-quarter mile from the station and contained much sediment, as the sewage from a city of 20,000 inhabitants flowed into the stream a few miles above the intake to the pumps. A pasty substance similar to clay, congealed and covered the interior of the condenser tubes, which made it necessary to remove the condenser heads each morning during the light-load hours and blow out the tubes. At about the time the peak load came on, at 5 p.m., the vacuum would begin to drop, especially on the 2,000-kw. units, on account of the plugged tubes.

The day operator was relieved by the night operator at 6 p.m., and each night as he came on duty he found the following conditions: Steam pressure down to 145 lb., normally 175 lb.; vacuum on the two 2,000-kw. units at 25 in., while it should have been 28 in. Furthermore, each of the 2,000-kw. units was carrying approximately 3,200 kw., while the two 1,000-kw. units had only 500 kw. apiece with the vacuum at 28 in. The night operator evolved a plan. He loaded the two 1,000-kw. units until

he brought the load to normal on the two 2,000-kw. units, allowing the condensers to become cooled sufficiently to bring the vacuum to normal. The excess load occasioned by the extra night service was readily handled by the two 1,000-kw. units at normal vacuum, and in less than thirty minutes after taking over the shift, with the same approximate total load, conditions were changed to such an extent that the safety valves on the boilers were on the point of blowing off. WAYNE G. BROOKINS.

Lyons, N. Y.

[There are probably few plants in which the engineers would not immediately have thrown more load on the underloaded machines, which also carried a higher vacuum. But this story shows that the obvious is not always obvious.—Editor.]

Pipe-Fitting Suggestions

In the article on "Pipe-Fitting Suggestions," by W. D. Forbes, in the issue of Dec. 28, 1915, page 895, he does not particularize, and it is to be inferred that his suggestions apply to the whole field of pipe fitting.

Current practice has long since abandoned the screwed fitting for even moderate pressures in steam and other service. Screwed fittings larger than 4-in. are rarely found on live-steam lines in power-plant work. In many of the modern power plants where high pressures and superheat are used, all live-steam lines 1½-in. and larger are flanged. In high-pressure ammonia work flanged fittings as small as ½-in. are regularly installed. In exhaust lines, low-pressure heating systems and similar installations, screwed fittings up to 12-in. are sometimes used because of the saving in the first cost of material. Above 12-in. screwed fittings are exceedingly rare, and the general practice for all classes of installations is to use flanged fittings above 6-in. or 8-in.

Although twenty years ago screwed fittings were more generally used, and there are good reasons why the screwed fitting has lost most of its past prestige, I do not advocate the universal adoption of flanged fittings. There are many instances where their use would be highly impractical both as to service and first cost, but fittings 1-in. and larger for steam at 100 lb. pressure and over should be flanged because they are unquestionably stronger. Against this there is no argument. They are also cheaper to install and replace and cheaper in ultimate cost, as any practical fitter or erector will agree. To slip a 4-in. flanged tee in place and make three flanged joints should take two men not over 30 min. To screw two 20-ft. lengths of 4-in. pipe into a screwed tee in place and make the joints steam-tight by man power will average not less than two hours under ordinary conditions. To make up a lot of 4-in. screwed fittings to exact center to center measurements is next to impossible when the accepted practice among fitting manufacturers permits a variation in tapping of one thread above or below gage, so that each thread means ⅛ in. variation in length.

In a correctly made screwed flanged joint the flange is screwed on until the pipe extends through at least two threads, and both pipe and flange are then faced off perpendicular to the axis of the pipe, assuring parallel faces and the exact length required. It is simpler to screw a flange tight on the pipe (even in the field) than to make up the pipe into a fitting in place.

Birmingham, Ala. W. LEE ROUECHE.

Difficulty with Suction Line

In the issue of Dec. 21, page 867, Alexander Arnois tells of his suction-line troubles and shows the general layout of the pipe in which a 36-in. line extends for 90 ft., branching off to two 24-in. lines with a Y-connection, and one of those 24-in. lines has four reciprocating pumps with 14-in. suctions connected to it.

The combined area of those four suctions far exceeds the area of the 24-in., and when the four pumps are operating this has a tendency to diminish the supply for the centrifugal pump, but his greatest trouble and perhaps all his trouble is in the drop legs of the main suction.

The diagram shows that the diameter of the two drop legs into the well is also 24 in. each, and that they connect to the common 36-in. section, their combined area being 904.77 in., against 1,017.87 in. for the 36-in. line; therefore the suctions at the foot valves are contracted. This creates a tendency to collect trash around the foot valve on account of the high velocity of the water at that point and may account for the extraordinary vacuum. The area of the combined drop legs should be greater than the main suction to avoid the collection of trash at the foot valves. I would suggest that another drop leg at least 14 in. diameter, which would be slightly greater than the area of the 36-in. line, be used to eliminate the trouble. JOHN FITZSIMMONS.

New York City.

Oiling Valve Dashpots

The operation of nonreturn valves is not always understood and appreciated. In one case I saw several of the globe type placed endwise in the pipe line. In this position the steam pressure in the boiler would force the valve open, but it had to be shut by hand and in the event of accident to the boiler would have been useless as an automatic stop valve. Some pipe fitter had made the mistake.

My experience with nonreturn valves has rather prejudiced me against some types in which the rings of the dashpot piston, if not lubricated, may corrode and cause sticking. It seems to me that provision for lubricating the valve internally would be good. Lack of lubrication also causes the valve to stick and then perhaps suddenly operate, and I have seen valves that refused to open at all.

Brooklyn, N. Y. WARREN D. LEWIS.

Boiler Leaks Caused by Unequal Expansion

For the benefit of A. W. D. or others who may be troubled with leaky boilers where shavings or mill refuse is used for fuel, as referred to under "Inquiries of General Interest," page 801, Dec. 7, 1915, issue, I can testify that leakage from unequal expansion may be due to other causes than the use of that kind of fuel or the particular method of firing.

We have 17 boilers, all of which are run day and night except 2 return-tubular boilers with dutch-oven furnaces that are operated only during the day shift, using shavings and mill waste as fuel. This pair of boilers developed leaks that could not be stopped. It was noticed that in the mornings the lower parts of the boilers would be cool, while portions next to their steam spaces would be warm,

owing to leakage of steam from the other boilers through the nonreturn stop valves. Most of the cooling was found to result from drafts of cold air sweeping over the heating surfaces of the boilers from leaving ashpit doors and uptake dampers open during the night, thus causing unequal expansion of the boilers. After repairing the leaky blow-back valves and keeping fire and ashpit doors and uptake dampers closed when the boilers were not in use, no further trouble was experienced from leaky joints or tubes. R. A. HAFFORD.

Groveton, N. H.

Sealing Water Used in Boilers

The letter, "Sealing Water Used in Boilers," in the Jan. 18 issue, was interesting and instructive. The system described by Mr. Coleman is practically the same, but not so complicated as the one about which I write.

In this turbine plant there is a service pump which carried a pressure of 50 lb., but the water was unsuitable for use on the water seals, so it was necessary to use city water at 65 lb. pressure. However, it was desired to have the service-pump water for use if the city water failed, and to accomplish this both were piped through 1-in. pipes into a 1¼-in. header with a check and globe valve in the 1-in. pipe from service and city water sources, so that when the city-water pressure drops below 50 lb. the check in the service line will open and furnish the supply. There is an alarm in the city line that rings if the pressure drops.

After passing through the seals the water overflows about twenty feet above the turbine, but instead of overflowing directly into the return pipe, it drips through a little cooling tower, is then collected and used to cool the cylinders of a small air compressor, after which it goes to the feed-water heater. T. CRAVEN.

Waycross, Ga.

Why Did the Valve Fail?

The failure of cast iron is of a frequent occurrence and often happens when least expected. The sketch shows the failure of a cast-iron, 10-in., high-pressure angle valve. This accident happened in a large central-station plant having forty 500-hp. Babcock & Wilcox boilers, 180 lb. steam pressure, 100 deg. superheat. The valve that failed connects the saturated-steam line from the boiler to the header and was never used, being kept closed. The accident occurred at 5:30 a.m., when the boiler was being put into service to meet the increased load demands.

I would like to have the opinion of others as to what caused the valve to fail. This is the second valve that has ruptured in this plant, and the accident is a duplicate of the first, although it happened to another boiler.

Kansas City, Mo. A. E. RAMSEY.

What Caused the Pressure Fluctuation?

A 150-hp. horizontal tubular boiler had been out of service for 18 hr. and the gage still showed 40 lb. pressure. The safety valve was raised for a moment to make sure that the pressure was due to steam and not air. Then a wood fire was kept going for half an hour, when unexpectedly the pressure suddenly fell to 30 lb. where it remained for 10 min., after which it rose normally until 80 lb. was reached and the boiler was cut in service.

My theory of what took place is this: During the 18 hr. that the boiler was out of service, the hottest water naturally went to the top, being kept hot by the brickwork, while the coolest water settled quietly to the bottom. When the wood fire was started, most of the heat was absorbed by the water just over the grate, until the temperature of the water there corresponded to the pressure—that is, 40 lb.—when suddenly circulation was accelerated, which swept the water from the cooler parts of the boiler into circulation and brought the pressure down to 30 lb. CHARLES HAEUSSER.

Albany, N. Y.

[The first question that suggests itself is: Was the gage in correct working condition? It is likely that the pressure would have become reduced before such a temperature difference in the water at the top and that at the bottom could have existed. However, the question is interesting and discussion is welcomed.—Editor.]

Relief Valve on Blowoff Pipe

An article in a recent issue of a paper published by a valve manufacturer suggests the use of a spring-loaded relief valve on the blowoff pipe of a boiler as a precaution against damage from water-hammer.

I cannot imagine anyone installing a spring-loaded valve on the blowoff line of a boiler. Should the safety valve on the boiler happen to stick and the steam pressure rise high enough to relieve the pop on the blowoff line, or should the spring in the blowoff pop weaken or break, this would automatically blow the water out of the boiler, leaving it partly or totally dry. The result might be disastrous.

From a safety standpoint imagine the boiler tender opening or closing the blowoff valve, standing directly in front of the pop safety valve. Should the pop valve relieve, the operator at the blowoff valve would surely be scalded.

This should receive publicity at once, as it may prevent some innocent water tender from being seriously scalded or somebody's boiler from being blown up.

San Francisco, Calif. V. R. HUGHES.

Utilizing the Exhaust Steam

In this plant an exhaust superheater is used to raise the temperature of the exhaust steam to 450 deg. F., after which it is used in the process of gas making at a pressure of 3 lb. Formerly, part of the plant was operated condensing and part noncondensing, but live steam was used in the production of the gas, and 4 rated 350-hp. boilers had to be used. Since using the superheater 3 boilers carry the load, saving some 24 tons of coal a day. Drip oil taken from the gas accumulators is used in the separately fired superheater.

No figures are available as to the actual saving effected, but that the installation is successful is shown by its adoption in several other plants that belong to the same company. ALEX BLOM.

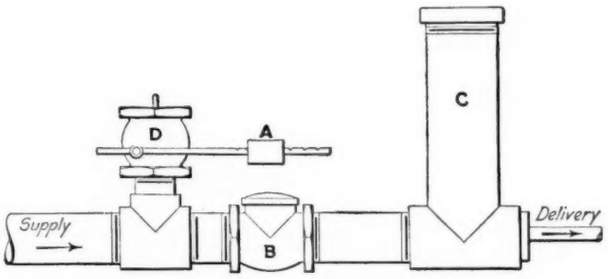
Chicago, Ill.

[This method of utilizing exhaust steam at low pressure, by superheating it, is capable of more general use, and inexpensive equipment will do the work.—Editor.]

An Easily Made Hydraulic Ram

Some of the simple devices and ideas contributed by our fellow-workers are of great value, and the way in which they share these ideas for the benefit of others is pleasing.

A hydraulic ram made from fittings easily obtained is shown in the illustration. I cannot vouch for its efficiency, but know that it does the work very well. It consists of an inverted back-pressure valve *D*, a check-valve *B* and an air chamber *C*, with a few fittings and



HOME-MADE HYDRAULIC RAM

connecting nipples, and the operation is simple. After connecting the ram with a source of supply which should have a fall of at least three or four feet, it is started by opening valve *D* enough to allow the water to escape freely, so that there is friction or force enough against the valve to lift and close it quickly. This will cause a ram, or water-hammer, that will open *B*, allowing the excess pressure to escape into air chamber *C* and thence to the delivery pipe. Should valve *D* fail to open itself after a short time, open it by pressing down on the lever a few times until some pressure has accumulated in the air chamber *C*; then, if the adjustment at *A* is correct, it will operate without further attention.

In the valve I used, there was room, or "play," enough in the slot under valve *D* to allow it to close and open without tilting the walking-beam lever. The adjustment at *A* regulates the amount of opening at *D*, which in turn determines the number of strokes per minute. The supply should be kept free of any foreign matter that would keep either valve open. HENRY F. GRAY.

Boston, Mass.

Overspeed and Overpressure

The following experience may be of interest to readers of *Power*: A hydraulic baling press recently installed had a 3-cylinder horizontal power pump to supply the pressure. A 15-hp. 1,200-r.p.m. induction motor was purchased second-hand to drive this pump through a countershaft, the reduction of speed being calculated to give 120 r.p.m. at the pump shaft, and the pump was provided with a relief valve set at 2,000 lb.

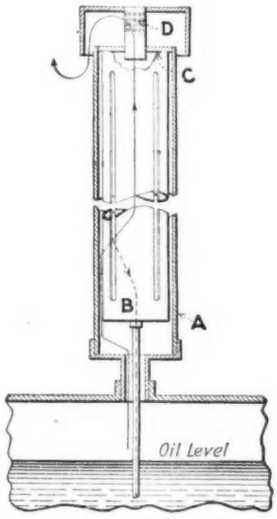
On starting up trouble was soon experienced with the breaking of the pump glands. These glands were each held into the pump stuffing-box by two ¾-in. stud-bolts, and the pump was packed with about five rings of rawhide packing. This packing was forced out, breaking the glands and bending the studs outward. It was at first thought that there was some obstruction in the discharge line, causing the pump to work against too great a pressure, and that the relief valve was perhaps inoperative. All possible sources of trouble of this kind were investigated, and everything was found in good condition. The trouble with the breaking of the glands, however, still continued. After everything else had been tried, it was finally suggested that the pump might be running over speed. A speed counter was therefore procured, and it was found that the pump was running at about 175 r.p.m. instead of at the proper speed of 120 r.p.m.

On testing back it was found that the motor, although stamped 1,200 r.p.m., was actually running at 1,800 r.p.m. The reason for the breakages was then evident—the pump was delivering oil faster than the discharge pipe could take it away, and even with the relief valve the pump could not get rid of the oil fast enough. This caused overpressure, and the glands, being the weakest, gave way first. The speed was corrected, and no further trouble has been experienced. LEO S. WEIL.

New Orleans, La.

Vent for Turbine Oil Well

The air vent on the oiling system of a steam turbine caused considerable annoyance by blowing oil out with the air. It blew air continually, and when the oil got frothy much oil came out. The device shown allows free vent for the air, and since its application no oil blows out. The vent is made as follows: A piece of 1½-in. pipe *A* about 10 in. long forms the body; a 1½x½-in. reducing coupling at the bottom and a ½-in. nipple connect the body to the oil well on the turbine. The part *B* is a piece of 1¼-in. brass tube 8 in. long, with four slots in the sides. A disk *C* is soldered in the top of the 1½-in. pipe and soldered to the inner tube *B*; a ⅜-in. nipple *D* has many holes drilled in it and is soldered to a 2-in. cap. In the bottom of *B* is a plug drilled and tapped for a ⅛-in. pipe which extends down below the oil level in the oil well. The solid line shows the path of the air, and the dotted line shows the path of the oil.



TURBINE OIL-WELL VENT

Washington, D. C. MORRIS ELLISON.

"Heavy" or "Light" Steam Gages

Confusion resulting from the application of the terms "heavy" or "light" to pressure gages can be avoided by the use of the words "high" or "low" in the sense of distance above or below the correct reading. Observation of distance from a certain mark is the first consideration in the comparison of any gages.

The words "fast" and "slow," indorsed by W. R. Morton, page 55, Jan. 11 issue, are terms of time rather than of location on a scale. D. MCGREGOR.

Newark, N. J.

Cylinder-Lubrication Costs

Prior to two years ago all cylinder oil used in the Capitol Power Plant, Madison, Wis., had been bought under specifications. While the results had been quite satisfactory, it seemed possible that the best had not always been obtained, so it was decided to test the different brands under operating conditions to determine their relative values. Some preference had been given to oils compounded from Eastern crude, and unfiltered oils had not been admitted under the specifications. In the tests no restrictions were placed on the source of supply, ingredients, or method of refining or compounding of any oil offered for trial, but all were judged on the following basis: The relative quantity required to keep the cylinder and valves properly lubricated; relative condition of the cylinder and valves after the end of the test period as determined by inspection; deposits in oil ways, exhaust passages and separators; and the cost of the oil delivered at the plant in barrel lots.

All tests were run on one side of a twin Corliss engine, cylinders 14x36 in. and fitted with a 1-qt. sight-feed lubricator, a double connection with the feed pipe running in to the center of the steam line to the engine. Glycerin was used in the sight-feed glass. The engine speed was 120 r.p.m., the cranks at 90 deg., steam pressure 140 lb., gage, no superheat, back pressure 5 lb., gage. The steam lines to the engine were 5 in., connecting by long-radius bends to angle valves on top of a 10-in. header. The 5-in. bends were drained by vertical steam separators above the engine throttles with gravity drain to a drip main in the basement. No indication of water in the engine cylinders has ever been observed.

The method of testing was as follows: A careful inspection of the internal surfaces of the cylinder, piston and valves was made prior to the starting of the tests by engineers of the plant in the presence of representatives of any oil manufacturers who desired to witness it. Observations were carefully noted and covered the following: Lubrication as evidenced by the surface appearance; pitting or steam cutting at any point; deposits in oil grooves, under the packing rings, or on the surfaces of the ports or passages; and any other condition that might have a bearing on the subject.

Before starting each test the cylinder walls, packing rings, valves and seats, and the passages as far as possible, were cleaned of any deposits. The oil under test was accurately weighed and the feed adjusted to give the minimum amount that would effect smooth and quiet operation. An accurate log was kept of all running time, amount of oil used, feed per minute and any incidents in connection with the tests. At the close of each test a second inspection was made and the observations were recorded. Each sample of oil submitted for test was given a number under which it was entered in the report; after the tests were completed, the data from each sample were computed and entered in the report under the number corresponding to the sample tested. Each competitor received a complete report and was advised which data covered the oil submitted by him.

On tests of eleven samples of oil, from November, 1913, to June, 1915, the amount of oil used per 1,000,000 sq.ft. of cylinder surface, valve surface not included, varied from 4.75 oz. maximum to 2.35 oz. as a minimum. The cost of the different oils varied from 35c. per gal. to 90c. in barrel lots, and the cost per 1,000,000 sq.ft. of surface lubricated was 2.6c. for the highest and ¾c. for the lowest. With all cases the lubrication was good and the condition of internal surfaces uniformly the same. Only one left any deposit in dead spaces and oil grooves. Two of the oils did not feed regularly in the hydrostatic lubricator. The oils tested included Eastern and Western stock, filtered and unfiltered, with Baumé test varying from 22.4 deg. to 26.3 deg.

An average of the results from the eleven tests shows the lubrication of 1,000,000 sq.ft of cylinder surface with 3.44 oz. of oil at a cost of 1.36c. The output for the unit on which the tests were made averaged 27,500 kw.hr. per month, with a cost for cylinder lubrication of approximately 3/1000c. per kw.hr. H. R. Dorman.

Madison, Wis.

Groaning in Steam Pump

In answer to Mr. Blondett's letter in the issue of Feb. 1, page 162, regarding the groaning in a pump since it has been overhauled, it occurs to me that the sound may be due to excessive friction through the valves or possibly because of too small an outlet connection for the water. We once had considerable trouble from noise and vibration because, as we found out later, there was not enough area through the valves and discharge pipe to allow the water to pass through them without excessive friction.

Mr. Blondett should see that the water valves are all working and have their full lift and then see if the feed line is not too small for the pump. M. Saller.

Philadelphia, Penn.

Boosting and Protective Unions and Professional Societies

Perhaps you have received a number of letters in regard to your editorial, "Boosting and Protective Unions and Professional Societies," in the issue of *Power* of Jan. 11, 1916. From the number of comments on it that I have heard, evidently you stirred up many people. I was mad myself, at first, but a second reading left me without malice.

The editorial was born of ignorance, and it seems that the fact that the organization of the "patent attorney" was the outgrowth of the other, whose objects and purposes you mentioned, as it saw no light in the then existing unionistic tendencies of the mother, will knock flat your argument. I might add that the child has outgrown the mother. O. F. Gayton,

Chicago, Ill. Department of Public Service.

The editorial on page 52 of *Power,* issue of Jan. 11, 1916, entitled, "Boosting and Protective Unions and Professional Societies," bristles with inuendoes against our association and its secretary. This, according to the editor, "split upon the question as to whether it should give legal advice gratis to its members in patent matters." The American Association of Engineers never gave, nor does it intend to give, legal, patent or any other professional advice free to its members or anyone else. It will take official action in case a legal or patent question affects the profession as a whole or any part of it.

Its secretary pleads guilty to being a patent attorney (and incidentally a telephone engineer also), just as its president is a gas engineer, its vice-president a power engineer and each of its members some kind of an engineer. Since he undertook the new work, the secretary has temporarily neglected his private practice until such time as the association work is well established and accepted by engineers and the public on the plane on which its original promoters have undertaken to place it.

The Associated Technical Men came into existence before the American Association of Engineers, the latter being formed by men who felt that they could not subscribe to and support some of the policies proposed at that time by the Associated Technical Men. The A. T. M. is said to have about 100 members; the A. A. E. has 385 members.

It is the purpose of the A. A. E. to elevate the standard of the engineer, and it believes that the field for associations is vast and the past has shown that no one society has been able to accomplish all the activities to be pursued in benefiting the engineer. We hope that all associations whose ultimate purpose is to aid the engineer will thrive and succeed in securing benefits and increasing the proficiency of their members.

The policies adopted by the A. A. E. have not been changed since the inception of the association; for time and a fair trial of them have demonstrated their stability, wisdom and satisfaction. If time or experience should dictate the wisdom of a change in policy to benefit the individual engineer, his employer and the public, we are ready and willing to reconstruct our policies in accordance with the will of the majority of the membership.

In the meantime we take a charitable view of any dignified periodical that will resort to throwing mud without investigation, believing that we can afford to wait until this paper has accorded to us that fair and unbiased investigation which has changed those heretofore antagonistic to us to become our best friends and boosters.

We are pleased to know that this editorial did not originate in Chicago. Your Western representative, Thomas E. Wilson, called at our office and also attended our Booster Dinner in September and has formed a favorable opinion of us after the investigations he chose to make of our activities. We are sure that the editor who wrote this destructive criticism has not heard sufficiently about us or given the subject careful consideration.

We invite any investigation which your company or anyone else may wish to subject us to and consequently feel entitled to fair play. ARTHUR KNEISEL,

29 South La Salle St., Chicago, Ill. Secretary.

Little Damage from Low Water

A burst tube is shown in the photograph. The thinness to which the metal was drawn out before parting will be noticed. The manner in which the outrushing steam spread the ruptured part indicates how soft the metal must have been. The tube gave way under 150 lb. pressure, and although 15 men were at work near the boiler, no one was seriously hurt. Inwardly opening furnace doors prevented a large amount of steam being blown into the firing aisle, and a nonreturn valve precluded a serious drop in pressure in the other boilers.

In this plant automatic feed-water regulators had been installed. Ordinarily they worked well—so well that one of the water tenders had been removed. It had become a habit to let the water level take care of itself, and this caused the bottom gage-glass connection to become choked with scale; therefore the failure of the regulator to operate was not detected. The water appeared to be half-way up the glass, while the boiler was practically empty. Nearly every tube in the boiler was burned, as the furnace temperature averaged above 2,000 deg. F. That there were no fatalities or serious injuries is a fine exemplification of the safety of the water-tube boiler, and the fact that there was not a shutdown demonstrates the value of automatic stop valves.

RUPTURED TUBE

Providence, R. I. HENRY GAULT.

Preparedness

In these troublous times, when it is almost impossible to pick up a daily paper or magazine without finding an article upon national preparedness, it behooves the engineer to ask himself how well prepared he is to meet any emergency that may arise in his walk of life.

A great many engineers have an idea that if they do their work well and are satisfactory to their employers, their jobs are secure. But suppose some day, while you are dreaming of the dire happenings that would overtake the plant if you were not on the job, a bill goes through the legislature requiring upon your part a license to do some part of your work. Suppose further, that while you have always done this work, which is very essential to the upkeep of the plant, yet you know full well that you would not be able to pass an examination that would entitle you to a license to do it. How now about the security of your job?

Such a condition of affairs has come about in Massachusetts with the introduction of the new electrician's license law, which took effect Sept. 1, 1915. Engineers who in times past have performed all minor electrical work around their plants and such buildings as came under their supervision suddenly awake to find that if they wish to continue doing such work they must hold a journeyman's license, and many of us find that we will have to do some hard studying to prove our ability to do such work, when we face the examiners. Yet fair-minded engineers know that this is a line of work that should be licensed.

All this leads up to the constant need of preparedness upon our part to meet such changes and developments as come up in our work from time to time. Holding down a good job today means something more than being able to keep the wheels going around, for without study we are bound to find our field of endeavor gradually

growing smaller. The day of taking a monkey-wrench to prove one can do a job has passed, and it is not amiss to remember that the man at the roller-top desk gets bigger pay than the chap on the end of a No. 5 coal scoop.

The following questions, which comprise one of the recent examinations for journeymen electricians, may interest engineers who may have a similar examination to pass in the future, and it is worth more than passing study from all progressive engineers, as showing some of the things that an electrical worker should know to be up to date:

ELECTRICAL EXAMINATION QUESTIONS

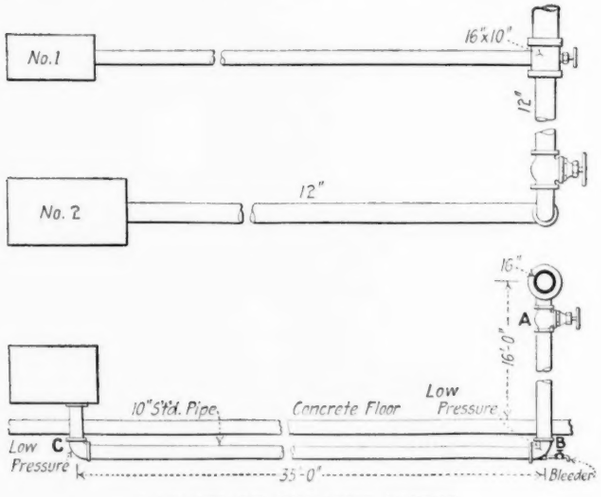
1. Is it necessary to ground metal molding?
2. Show how you would install an outlet for a heating appliance for 600 watts.
3. How would you install a combination fixture on a metal ceiling?
4. What is the greatest number of 50-watt lamps that may be used on a branch circuit?
5. What is the rule for installing lamps in damp places, such as refrigerators?
6. How many 660-watt circuits may be installed in one conduit?
7. How should a switch be installed in a mill where it is very dusty?
8. Why should a conduit be grounded?
9. If you placed a 6-amp. fuse in a circuit and it blew out, what would you do?
10. How would you install a wooden molding on an outside brick wall?
   a. Draw diagram of wiring for one light to be controlled from three places.
   b. Draw wiring for a series motor, showing what devices you would place on the circuits.
   c. Show how you would use five 110-volt lamps in a 550-volt circuit.
   d. What is the difference between a voltmeter and an ammeter?

Dorchester, Mass. A. D. PALMER.

Accident Narrowly Averted

The exhaust piping in a large plant was arranged as shown in the illustration, with valve *A* about 16 ft. above the floor. This valve had been closed during the night in order to pack No. 1 engine.

The oiler whom I sent up to see if it had been opened reported that it had, so I opened the throttle slowly,



LAYOUT OF EXHAUST PIPING

but the engine turned over only a few times and then stopped. After a second trial I examined the valve *A* myself and found that the oiler had made a mistake, thinking the valve to be open when it was really hard closed. This incident set me thinking of what might have been the result if some part of the low-pressure piping system had exploded when the full boiler pressure (140 lb.) was put on it instead of the 25 lb. for which it was guaranteed. I believe it is a mistake, for the small difference in first cost, to use low-pressure fittings on exhaust lines when there is danger of their being subjected to high pressure at some time by an occurrence such as that described—and surely the possibilities are numerous.

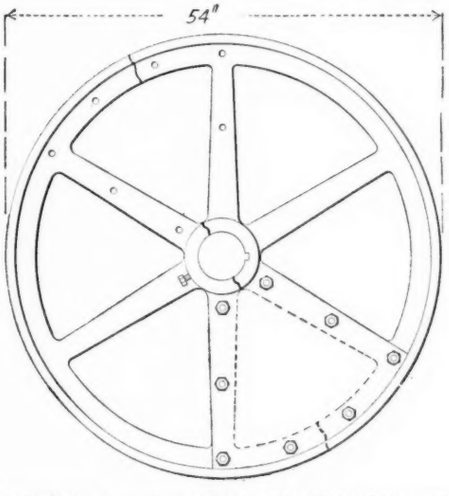
A valve with a rising stem is preferable, especially in such a position, because it is easy to determine even from a distance whether it is open or closed. A small pop valve with a whistle attached, if connected into the exhaust line, would give timely warning of excessive pressure, whatever the cause may be, and help to avoid an accident. H. G. SCHULER.

Kansas City, Mo.

Inexpensive Pulley Repair

A large iron pulley was broken as shown in the illustration. After the holes for 5/8-in. bolts were drilled in the spokes and rim, the wheel was clamped together and a templet taken for the 1/4-in. sheet-iron pieces (four in all), which were obtained from a near-by boiler shop. One of these pieces was bolted to each side, but there was no band or ring shrunk on the hub or pulley face.

The pulley was put in service and never caused any trouble during the years it was in use. The part of the



METHOD OF REPAIRING BROKEN PULLEY

repair work that was done at the plant was completed in about two hours by the regular power plant operating force on duty.

It is understood of course that such a repair cannot be used on a pulley or wheel subjected to severe strain or high speed because the danger of breakage when in service, with the consequent damage and possible personal injury, would more than offset the saving by the use of the old pulley. In any case the work must be carefully done and the pulley should be closely watched as long as it is kept in service to secure the greatest degree of security possible under the circumstances.

Toronto, Ontario. JAMES E. NOBLE.

Inquiries of General Interest

Rule for Roughly Estimating Size of H. R. T. Boiler—What short rule can be given for roughly estimating the nominal horsepower size of a horizontal return-tubular boiler?

J. R.

The nominal horsepower size of horizontal return-tubular boilers of ordinary proportions, as commonly rated, can be roughly estimated by multiplying the square of the diameter in feet by the length in feet and dividing the product by 5.

Employer's Property in Inventions of Employees—When a person is employed on a salary without contract and makes a patentable discovery, can he be compelled to turn the invention over to his employer if he is not obligated to do so under a special agreement of his contract of employment?

W. C. S.

An employee who is not under special contract to assign discoveries or inventions to his employer is not obligated by law to do so. Inventors are very likely to overestimate the intrinsic value of their inventions and, before deciding to secure a patent regardless of the interests of his employer, an employee should consider whether his position may not be worth more than a patent obtained with the displeasure of his employer.

Foaming of New Heating Boiler—In a new gravity-return steam-heating plant, trouble is experienced with foaming of the boiler. How can it be remedied? G. L.

The foaming may be due to the use of dirty feed water or water containing animal or vegetable substances. In a new heating system there is more or less oil and dirt present from machined fittings, radiator tapping and pipe threading that, together with core sand from radiator and other castings, works down into the boiler, causing it to foam. The remedy is to close all radiator valves and, with a steam pressure of 5 to 10 lb., draw the fire and blow all water out of the boiler, refilling it after it has cooled. As the water level is lowered, some of the oil that was present may adhere to the boiler surfaces, and to entirely remove trouble from foaming it may be necessary to repeat the operation several times.

Work of Pumping Reduced to Equivalent B.t.u.—How many B.t.u. are equivalent to the work of pumping 8,000,000 gal. of water against a pressure of 38 lb. per sq.in.?

W. A. A.

Assuming the temperature of the water to be 62 deg. F., each pound per square inch of pressure pumped against would be equivalent to a head of 2.309 ft., and pumping against a pressure of 38 lb. per sq.in. would be equivalent to raising the water $38 \times 2.309 = 87.742$ ft. A gallon of water at 62 deg. F. weighs 8.3358 lb., and for ordinary temperatures the weight is usually assumed as $8\frac{1}{3}$ lb. Therefore the net work performed in pumping 8,000,000 gal. of water against a pressure of 38 lb. per sq.in. would be $8\frac{1}{3} \times 8{,}000{,}000 \times 87.742 = 5{,}849{,}466{,}608$ ft.-lb. As 1 B.t.u. is equivalent to 778 ft.-lb., the net work performed would be equivalent to $5{,}849{,}466{,}608 \div 778 = 7{,}518{,}595$ B.t.u.

Quantity of Steam Required for Heating Water—What weight of steam at atmospheric pressure would have to be discharged into 20,937.5 lb. of water to raise its temperature from 47 deg. F. to 163 deg. F.? N. S.

The heat received by the water would be $20{,}937.5 \times (163 - 47) = 2{,}428{,}750$ B.t.u. According to the steam tables a pound of dry saturated steam at the pressure of 14.7 lb. per sq.in., or atmospheric pressure, contains 1,150.4 B.t.u. above 32 deg. F. In becoming condensed and cooled to water at 163 deg. F., each pound would part with $1{,}150.4 - (163 - 32) = 1{,}019.4$ B.t.u. Hence without allowing for any other losses of heat, as by radiation from the surface of the vessel containing the water to be heated or evaporation from the surface of the body of liquid heated, to raise the temperature of the water to 163 deg. F. would require $2{,}428{,}750 \div 1{,}019.4 = 2{,}382.5$ lb. of dry saturated steam.

Failure to Obtain Water from Boiler Try-Cock—Before starting up a boiler and with over two gages of water showing in the gage-glass, what would be the reason that no water can be drawn from the lowest water try-cock?

M. R.

If the gage-glass connections are open and the try-cock and its connections are not obstructed, failure to obtain a discharge from the try-cock would indicate that the pressure in the boiler is below atmospheric. This is a condition commonly experienced with heating boilers, owing to condensation of the steam in the system, and may occur with power boilers when the connections are left closed and the boiler has become cooled, as after standing for some time with the fires drawn. Neglect to leave a connection open to the atmosphere or to provide an inwardly opening check valve may thus expose a boiler to an injurious collapsing pressure of the atmosphere.

Time Required to Empty a Tank—A tank 12 in. square by 12 ft. high is open to the atmosphere at the top and provided at the bottom with an aperture which has an area of 1 sq.in. If filled with water, how long a time will be required to empty the tank if the water acting by gravity alone discharges through the aperture against atmospheric pressure without allowance of friction loss through the aperture, and how long a time will be required if the tank is closed at the top and an air pressure of 50 lb. gage is maintained throughout the operation of emptying? J. B. N.

The theoretical velocity of discharge through an aperture is given by the equation for the velocity of a body falling in vacuo, namely,

$$v = \sqrt{2gh}$$

in which

v = Velocity in feet per second;
g = 32.2, the acceleration of gravity;
h = Height, or head of the water, in feet, above the center of the aperture.

As in completely discharging, the final velocity would be zero, then with a vertical-sided tank, neglecting friction and retardation from inertia and friction of the liquid in moving laterally toward the aperture, the average velocity would be $(0 + \sqrt{2gh}) \div 2$, or $\frac{1}{2}\sqrt{2gh}$. Hence if $h = 12$ ft., the average velocity of the discharge would be

$$\tfrac{1}{2}\sqrt{2 \times g \times 12} = 13.899 \text{ ft. per sec.}$$

and the theoretical time in which the contents of the tank, or 12 cu.ft., would be discharged with that average velocity through an aperture of 1 sq.in. area would be

$$\frac{12}{\frac{1}{144} \times 13.899} = 124.3 \text{ sec.}$$

A pressure of 50 lb. gage acting on the upper surface of the water would be equivalent to superimposing a head of $50 \times 2.3 = 115$ ft. With like allowances for inertia and friction, the velocity of the initial discharge would be the same as though taking place under $12 + 115 = 127$ ft. head, and the velocity of the final discharge would be that corresponding to a head of 115 ft. Hence the theoretical average velocity of the discharge would be

$$(\sqrt{2 \times g \times 127} + \sqrt{2 \times g \times 115}) \div 2 = 88.247 \text{ ft. per sec.}$$

and the theoretical time required to empty the tank would be

$$\frac{12}{\frac{1}{144} \times 88.247} = 19.5 \text{ sec.}$$

In both cases the actual time will be greater than the theoretical, to cover the time required for establishing the initial velocity of the discharge and depression of the head over the orifice, due to inertia of the liquid and frictional resistance of the liquid in flowing toward the aperture. This will be especially true as the flow approaches final discharge as influenced by the position of the aperture in the bottom of the tank and in the case of a superimposed air pressure, the final discharge would be materially retarded by the air breaking through and partly filling the aperture.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—Editor.]

U. S. Government Investigates Water-Power Control

That eighteen corporations control more than one-half of the total water power used in public-service operations in the United States, while six corporations control more than one-fourth, is one of the features of a voluminous report made to the Senate by Secretary of Agriculture Houston with respect to the water-power situation in this country. The report, which comprises three very large volumes and which will not be printed as a public document because of its great size, presents the results of an investigation by the Forest Service during the past year.

This report was made in response to a Senate resolution of the last Congress, which called upon the Secretary of Agriculture to furnish the Senate with all the information in his possession as to ownership and control of the water-power sites in the United States, showing what proportion of such sites is in private control and by whom owned, and any facts bearing upon the question as to the existence of a monopoly in the ownership and control of hydro-electric power in the United States.

The data of which the Senate is now in possession present in far greater detail than has ever been attempted before an exhaustive analysis of the general power situation. The inquiry was made thus extensive, the report itself states, "because only by this means can a clear understanding be had of the relation of water-power development to general power development and of the movement toward concentration of control in the electric-power industry."

In addition to drawing attention to the comparatively small number of corporations which control the bulk of the water power used in public-service operations in the United States, the report discloses further relationships through common directors and principal officers. These data show, says the report, "a marked tendency toward association or community of interests, particularly between the principal holding companies."

Movement Toward Concentration

"Of all the primary power employed in the electrical industries and in manufactures in 1902," says the report, "11.2 per cent. was installed in commercial central stations. This proportion had risen to 23.8 per cent. in 1912, more than doubling in the ten years. This movement toward concentration is found in all sections of the United States. For the ten years (1902 to 1912) the rate of concentration is highest in the South Atlantic States, which had three times as great a proportion of primary power in commercial stations in 1912 as in 1902. The extent of concentration was greatest in the Western States. Fifty per cent. of all primary power of all kinds in the Mountain States in 1912 was owned by public-service corporations; 54 per cent. in the Pacific States. In California alone the proportion was three-fourths. Today, only three years later, public-service corporations own 90 per cent. of all the primary power in these two groups of states."

Revised figures of the potential water-power resources of the country place them at the minimum of 27,943,000 hp. and a maximum of 53,905,000 hp., the minimum representing the amount of power that could be developed from the use of the average annual minimum stream flow for the lowest two consecutive 7-day periods of each year, while the maximum represents the amount that could be developed from the use of the average maximum continuous stream flow available for six months during the year. The National Forests are stated to contain 30.4 per cent. of this minimum and 31.3 per cent. of the maximum, while over 72 per cent. of the country's total is found in the Mountain and Pacific States and 42 per cent. in the three Pacific Coast States. National Forest water-power amounts to 42 per cent. of the minimum and 43 per cent. of the maximum estimated power resources of the Western States.

While 80 per cent. of the total installed power from all sources in 1912 was steam power, and while nearly three-fourths of the total primary power installed in commercial and municipal central stations (or establishments for the sale of power) and in street and electric-railway plants was steam power, the preponderance of steam power is found, according to the figures given, in the Eastern States; and the percentage increase in water-power development for public-service use, in the three years since 1912, has been three times as great as in steam power. Primary power installation from all sources and for all uses increased in the eleven Western States 240 per cent. from 1902 to 1912, or more than 2½ times as rapidly as in the remainder of the United States. This includes primary power used directly in manufactures, 94 per cent. of which is found in the Central and Eastern States.

Development Greatest in West

Primary electric power increased 440 per cent. in the Western States between 1902 and 1912, as against 226 per cent. in the remainder of the United States, or nearly twice as rapidly, while the development per capita in the Western States in 1912 was 2½ times as great as in the remainder of the United States. In installed water power per capita the Western States had more than four times as much in 1912 as the remainder of the United States. There is at the present time, according to this report, an over-development in nearly all the power centers of the Western States, California, Oregon and Washington in particular showing installations far in excess of maximum demands.

Private power interests reported in 1912 a total investment, as represented by the item "Cost of Construction," of over $2,000,000,000, equivalent to $21.97 per capita and to an average of $301 per horsepower of primary power installation. Municipal stations reported an aggregate cost of $77,000,000 and a cost per horsepower installed of $138, or considerably less than one-half of the reported cost of commercial stations. This apparently wide discrepancy in favor of publicly owned enterprises is explained as probably due in main to financial statements by commercial stations in which "cost of construction, equipment and real estate" represented, not actual outlays, but the amount which will make assets balance liabilities. "In the majority of cases," states the report, "it would be more nearly correct to call this item 'Assumed present value of properties,' than to call it 'investment in' or 'cost of' such properties."

TABLE SHOWING POWER DEVELOPMENTS BY 87 LARGEST COMPANIES

No.	Name of Company	No. of States	No. of Stations	Individual Totals: Water Power	Individual Totals: Steam and Gas Power	Individual Totals: All Power	Individual Percentages: Water Power	Individual Percentages: All Power	Cumulative Percentages: Water Power	Cumulative Percentages: All Power
1	Stone & Webster	13	62	340,211	189,643	529,854	6.36	3.56	6.36	3.56
2	Commonwealth Edison Co. (Ill.)	1	4	0	511,150	511,150	0	3.44	6.36	7.00
3	Consolidated Gas Co. (N. Y.)	1	8	0	481,895	481,895	0	3.24	6.36	10.24
4	North American Co	3	30	5,583	420,377	425,960	0.11	2.86	6.47	13.10
5	H. M. Byllesby & Co	17	53	116,155	160,341	276,496	2.17	1.86	8.64	14.96
6	E. W. Clark & Co. Management Corporation	4	36	162,330	103,365	265,695	3.04	1.79	11.68	16.75
7	Pacific Gas and Electric Co. (Calif.)	1	13	152,080	108,540	260,620	2.84	1.75	14.52	18.50
8	Interborough Metropolitan Co. (N. Y.)	1	2	0	246,500	246,500	0	1.66	14.52	20.16
9	Public Service Corporation of New Jersey	1	16	0	232,905	232,905	0	1.57	14.52	21.73
10	Doherty Operating Co	14	43	43,100	180,401	223,501	0.81	1.50	15.33	23.23
11	Southern Power Co. (S. C., N. C.)	2	9	157,850	47,010	204,860	2.95	1.38	18.28	24.61
12	Utah Securities Corporation	3	43	171,702	30,374	202,076	3.21	1.36	21.49	25.97
13	Brooklyn Rapid Transit Co. (N. Y.)	1	5	0	198,025	198,025	0	1.33	21.49	27.30
14	Pacific Light and Power Corporation (Calif.)	1	13	117,950	79,300	197,250	2.21	1.32	23.70	28.62
15	Montana Power Co	1	19	179,700	8,300	188,000	3.36	1.27	27.06	29.89
16	International Paper Co	5	23	156,830	29,945	186,775	2.94	1.25	30.00	31.14
17	United Gas and Electric Corporation of Connecticut	9	17	5,250	181,110	186,360	0.09	1.25	30.09	32.39
18	Commonwealth Power, Railway and Light Co	4	47	70,813	112,160	182,973	1.32	1.24	31.41	33.63
19	The Philadelphia Co. (Pennsylvania)	1	10	0	161,508	161,508	0	1.08	31.41	34.71
20	Hydraulic Power Co. of Niagara Falls	1	3	153,000	0	153,000	2.86	1.03	34.27	35.74
21	Edison Electric Illuminating Co. (Mass.)	1	3	0	140,850	140,850	0	0.95	34.27	36.69
22	Central States Electric Corporation (Ohio)	1	1	0	135,700	135,700	0	0.91	34.27	37.60
23	South California Edison Co.	1	11	56,400	79,120	135,520	1.06	0.91	35.33	38.51
24	Georgia Railway and Power Co.	1	7	100,400	33,720	134,120	1.88	0.90	37.21	39.41
25	Boston Electric Railways Co. (Mass.)	1	6	0	126,300	126,300	0	0.85	37.21	40.26
26	Washington Water Power Co.	2	5	109,200	16,000	125,200	2.04	0.85	39.25	41.11
27	Pennsylvania Water and Power Co.	1	2	118,000	0	118,000	2.21	0.79	41.46	41.90
28	The Niagara Falls Power Co. (N. Y.)	1	2	115,000	0	115,000	2.15	0.77	43.61	42.67
29	Western Power Co. (Calif.)	1	4	73,330	38,670	112,000	1.37	0.76	44.98	43.43
30	American Gas and Electric Co.	5	20	0	109,970	109,970	0	0.74	44.98	44.17
31	Philadelphia Rapid Transit Co.	1	5	0	105,730	105,730	0	0.71	44.98	44.88
32	New York, New Haven and Hartford Railroad Co.	3	16	8,050	96,500	104,550	0.15	0.70	45.13	45.58
33	W. S. Barstow & Co., Inc.	7	32	13,475	82,545	96,020	0.25	0.65	45.38	46.23
34	New York Central and Hudson River Railroad Co.	1	4	22,325	70,800	93,125	0.42	0.62	45.80	46.85
35	American Power & Light Co.	4	40	22,978	69,221	92,199	0.43	0.62	46.23	47.47
36	Twin City Rapid Transit Co. (Minn.)	1	3	25,000	66,700	91,700	0.47	0.62	46.70	48.09
37	Alabama Traction, Light and Power Co.	1	7	72,500	18,920	91,420	1.35	0.61	48.05	48.70
38	United Railways Investment Co. (Calif.)	1	5	65,600	25,330	90,930	1.23	0.61	49.28	49.31
39	Middle West Utilities Co.	9	118	16,824	69,890	86,714	0.31	0.59	49.59	49.90
40	Pennsylvania Railroad Co.	2	2	0	85,370	85,370	0	0.57	49.59	50.47
41	New England Power Co. of Maine	2	7	80,700	700	81,400	1.51	0.55	51.10	51.02
42	Lehigh Coal and Navigation Co. (Penn.)	1	4	5,367	70,500	75,867	0.10	0.51	51.20	51.53
43	Kings Co. Electric Light and Power Co. (N. Y.)	1	3	0	74,670	74,670	0	0.50	51.20	52.03
44	San Joaquin Light and Power Corporation (Calif.)	1	8	40,150	28,950	69,100	0.75	0.47	51.95	52.50
45	Ohio Traction Co.	1	6	0	65,611	65,611	0	0.44	51.95	52.94
46	Virginia Railway and Power Co.	1	4	19,000	46,420	65,420	0.36	0.44	52.31	53.38
47	Illinois Traction Co.	3	36	4,415	59,026	63,441	0.08	0.42	52.39	53.80
48	United Railways and Electric Co. of Baltimore	1	4	0	61,875	61,875	0	0.42	52.39	54.22
49	Northwestern Power Co. (Minn.)	1	2	57,000	4,670	61,670	1.07	0.42	53.46	54.64
50	C. H. Tenney & Co.	4	18	10,730	50,728	61,458	0.20	0.41	53.66	55.05
51	Pub. Service Co. of No. Ill.	1	13	5,300	55,930	61,230	0.10	0.41	53.76	55.46
52	American Water Works and Electric Co.	3	14	0	59,097	59,097	0	0.40	53.76	55.86
53	Consolidated Gas, Electric Light and Power Co. (Md.)	1	7	1,000	56,710	57,710	0.02	0.39	53.78	56.25
54	Massachusetts Electric Cos.	1	13	0	57,575	57,575	0	0.38	53.78	56.63
55	Pillsbury Flour Mills Co. (Minn.)	1	2	57,500	0	57,500	1.07	0.38	54.85	57.01
56	Washington Railway and Electric Co. (D. C.)	1	1	0	53,800	53,800	0	0.37	54.85	57.38
57	Kansas City Railway and Light Co. (Mo.)	1	1	0	53,300	53,300	0	0.36	54.85	57.74
58	Carolina Power and Light Co. (N. C.)	1	9	44,400	7,725	52,125	0.83	0.35	55.68	58.09
59	American Gas Co.	5	17	15,525	36,350	51,875	0.29	0.35	55.97	58.44
60	United Light and Railways Co.	2	7	500	50,025	50,525	0.01	0.34	55.98	58.78
61	New England Investment Co. (Mass.)	1	4	49,400	0	49,400	0.93	0.33	56.91	59.11
62	Nevada-California Power Co. (Calif.)	1	7	37,750	10,670	48,420	0.70	0.33	57.61	59.44
63	Detroit United Railways	1	9	0	46,986	46,986	0	0.32	57.61	59.76
64	Colorado Power Co.	1	7	41,750	4,870	46,620	0.78	0.31	58.39	60.07
65	J. G. White & Co.	4	17	20,880	25,599	46,479	0.39	0.31	58.78	60.38
66	American Public Utilities Co.	3	9	13,350	31,895	45,245	0.25	0.30	59.03	60.68
67	American Light and Traction Co.	4	5	13,400	31,584	44,984	0.25	0.30	59.28	60.98
68	Louisville Traction Co.	1	2	0	44,130	44,130	0	0.30	59.28	61.28
69	United Gas Improvement Co.	4	9	350	43,641	43,991	0.01	0.30	59.29	61.58
70	Chattanooga & Tenn. River Power Co. (Tenn.)	1	1	42,000	0	42,000	0.79	0.28	60.08	61.86
71	National Securities Corporation	2	4	39,350	2,000	41,350	0.73	0.28	60.81	62.14
72	Indianapolis Light and Heat Co.	1	1	0	40,900	40,900	0	0.27	60.81	62.41
73	Niagara, Lockport and Ontario Power Co. (N. Y.)	1	1	40,000	0	40,000	0.75	0.27	61.56	62.68
74	Aluminum Co. of America (N. Y.)	1	2	40,000	0	40,000	0.75	0.27	62.31	62.95
75	Columbia Gas and Electric Co. (Ohio)	1	1	0	38,930	38,930	0	0.26	62.31	63.21
76	Georgia Light, Power and Railway Co.	1	3	33,000	4,750	37,750	0.62	0.26	62.93	63.47
77	Turners Falls Power Co. (Mass.)	1	2	36,900	0	36,900	0.69	0.24	63.62	63.71
78	Pacific Lighting Corporation (Calif.)	1	1	0	34,202	34,202	0	0.23	63.62	63.94
79	Columbia Railway, Gas and Electric Co. (S. C.)	1	2	26,000	7,330	33,330	0.48	0.23	64.10	64.17
80	Northern Ohio Traction and Light Co.	1	2	2,270	31,000	33,270	0.04	0.22	64.14	64.39
81	United Properties Co. (Calif.)	1	6	0	33,025	33,025	0	0.22	64.14	64.61
82	Federal Light & Traction Co.	7	12	0	32,373	32,373	0	0.22	64.14	64.83
83	Ft. Wayne and North Indiana Traction Co.	1	3	0	32,160	32,160	0	0.22	64.14	65.05
84	United Illuminating Co. (Conn.)	1	2	0	31,200	31,200	0	0.21	64.14	65.26
85	General Electric Co. (N. Y.)	1	3	31,000	0	31,000	0.58	0.21	64.72	65.47
86	Union Carbide Co. (Mich.)	1	1	30,800	0	30,800	0.58	0.20	65.30	65.67
87	Cohoes Co. (N. Y.)	1	1	30,000	0	30,000	0.56	0.20	65.86	65.87
	Totals for 87 corporations	48	1,042	3,521,423	6,275,092	9,796,515	65.86	65.87	65.86	65.87
	Municipal stations	48	1,600	231,525	496,984	728,509	4.33	4.90	70.19	70.77
	All other stations	48	4,299	1,593,751	2,752,367	4,346,118	29.81	29.23	100.00	100.00
	Grand totals		6,941	5,346,699	9,524,443	14,871,142				
	Total manufacturing power included			736,197	172,210	908,407				
	Central stations and electric railways, 1915			4,610,502	9,352,233	13,962,735				
	Central stations and electric railways, 1912			2,942,388	8,251,311	11,193,699				
	Increase 1912 to 1915			1,668,114	1,100,922	2,769,036				
	Per cent. of increase			36.2	11.8	19.8				

Note. All but two of the corporations listed hereon—the International Paper Co. (16) and the Union Carbide Co. (86)—are engaged in public service operations.

The power developments which utilize National Forest lands have 42 per cent. of the total developed power of the Western States—30 per cent. through occupancy with some part of the immediate generating plant and 12 per cent. through storage reservoirs. An additional 14 per cent. either occupies public lands outside the forests or depends directly upon storage reservoirs upon such lands, making 56 per cent. of the total developed water power of the Western States dependent upon the use of public lands, taking place under existing laws. Plants either now under construction or for which final permits have been taken out will provide a further increase equivalent to 20 per cent. of the total present Western water-power development.

The table gives statistics of the 87 largest power companies in the United States, 85 of these being public-utility companies.

Scotch Boiler Explodes

The illustrations show views of a recent boiler explosion at the Bitter Water Station of the Producers' Transportation Co. at McKittrick, Calif.

The No. 2 boiler of a battery of five 125-hp. Scotch boilers carrying 125 lb. pressure ruptured in the corrugated furnace and passed out of the fireroom, through the walls of the engine room about 40 ft. away, and struck a large pump, damaging it. Fig. 1 shows the boiler after being moved a few feet from the pump. The front head passed over the pumps, out the other wall of the engine house, took part of the roof off a tool house, as shown in Fig. 2, and struck the ground 175 ft. away. Fig. 3 shows the damage to the rear of the boiler house, and Fig. 4 the front of the boiler house and boiler.

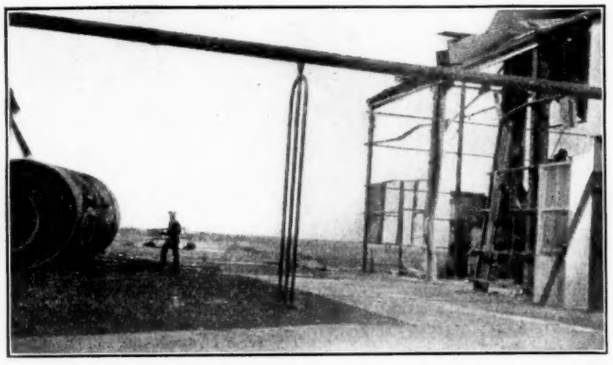
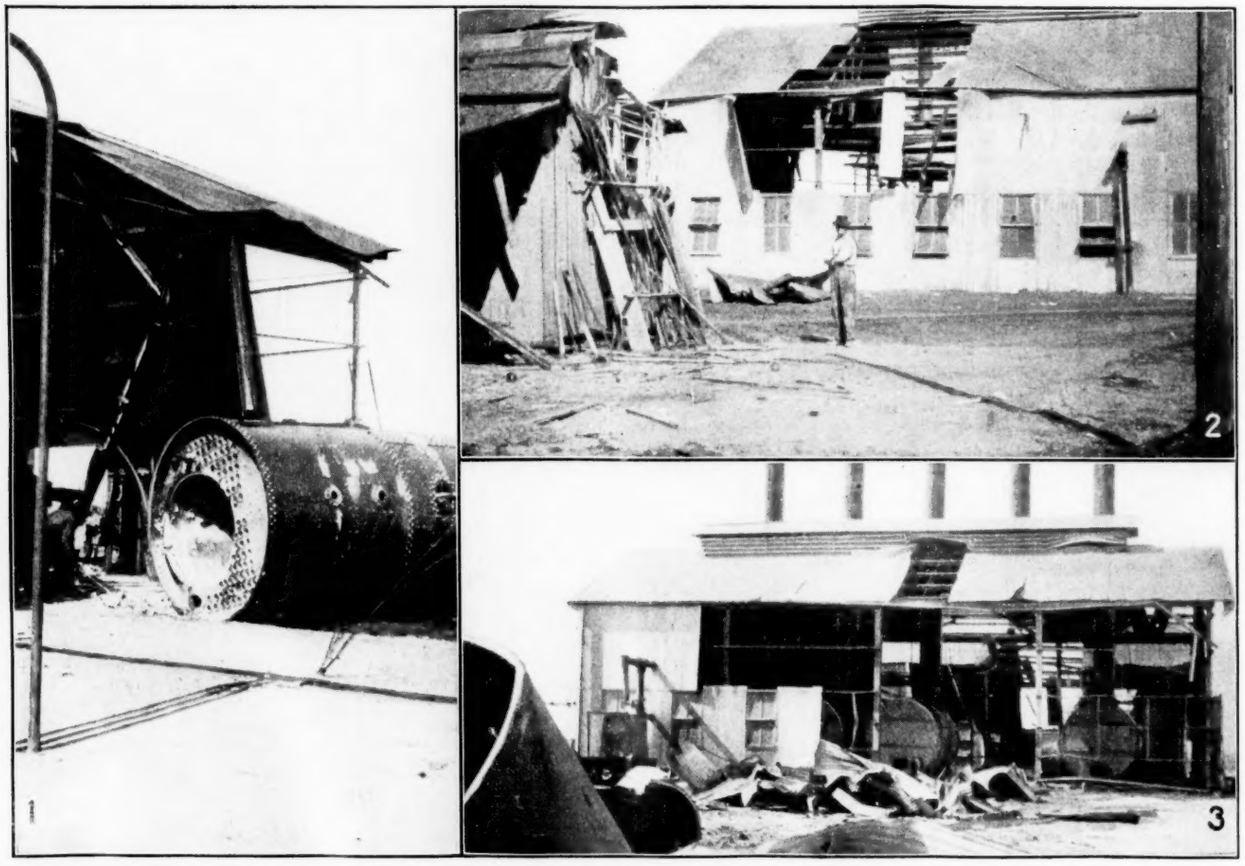


FIG. 4. THE BOILER BLOWN THROUGH THE BUILDING

The pictures were taken the next day, and the cause of accident had not been determined. The damaged boiler and also No. 1 boiler are being replaced by water-tube units.

Midwinter Meeting of A. I. E. E.

The fourth midwinter convention of the American Institute of Electrical Engineers was held at the headquarters in New York on Feb. 8 and 9. In his opening address, President Carty dealt with the engineer as a factor in the present movement for national preparedness, pointing out that although the engineer in the past had been somewhat overshadowed by some of the other professions in the consideration of public affairs, in the present crisis it was not the lawyer or the physician that the Government looked to, but the engineer, as evidenced by the personnel of the Naval Advisory Board. He then read a letter from President Wilson asking the institute to cooperate with the other great engineering societies in the appointment of a committee consisting of representatives from every state to canvass and report on the industrial prepared-



FIGS. 1 TO 3. VIEWS OF EXPLOSION OF INTERNALLY-FIRED BOILER

Fig. 1—The boiler shows little damage. Fig. 2—Damaged boiler house and tool house. Fig. 3—Showing where the exploded boiler stood

ness. Mr. Carty pledged the institute to the furtherance of this patriotic duty.

The first technical paper was by D. B. Rushmore, on "The A. I. E. E. and the Technical Committee." This reviewed the rapid growth of the electrical industry, which now embraces such a broad field that numerous specialized electrical engineering societies had sprung up. Mr. Rushmore believed that the institute, by somewhat modifying its organization, could embrace the broader field. To this end he made some tentative suggestions including a revision of the technical committees and the suggestion that the institute in conjunction with the National Electric Light Association, might compile handbooks on these special subjects.

The second paper of the morning was on "Municipally Operated Electrical Utilities of Western Canada," by Prof. A. G. Christie. This discussed the costs and methods of financing these plants and the political conditions under which they are managed. On the whole they have been very successful. A rather full abstract of this paper will appear later.

The papers of the afternoon session were: "Crest Voltmeters," by C. H. Sharp and E. W. Doyle; "The Crest Voltmeter," by L. W. Chubb; "The Voltmeter Coil in Testing Transformers," by A. B. Hendricks, Jr.; and "Notes on the Measurement of High Voltage," by William R. Work.

The Wednesday morning session was devoted to a symposium on electric-railway operation, including papers on "Operation on the Norfolk & Western Railway," by F. E. Wynne; "Chattering Wheel Slip in Electric Motive Power," by G. M. Eaton; and "The Liquid Rheostat in Locomotive Service," by A. J. Hall.

The final papers of the meeting were read on Wednesday afternoon; these were "Method of Determining the Connections of Polyphase Wattmeter Connections," by W. B. Kouwenhoven, and "The True Nature of Speech," by John B. Flowers, the latter dealing with the application to a voice-operated phonographic alphabet-writing machine.

The principal social feature of the convention was a dinner-dance at the Hotel Astor on Tuesday evening. Inspection trips were made to the Waterside Station of the New York Edison Co., the 201st St. Station of the United Electric Light and Power Co., the plants of the Interborough Rapid Transit Co., the Murray Hill Exchange of the New York Telephone Co. and the Electrical Testing Laboratories.

Water-Power Development in the Western States

Henry S. Graves, Forester of the Agricultural Department, is not in agreement with the present Secretaries of War and of the Interior, in the opinion that legislation to encourage and enable development of water powers under more liberal terms will bring larger development and use of hydro-electricity. In his annual report, just made public, the Forester says, in effect, that the reason there is not more rapid development of water power in the Western states is because there is no market for more power there.

With rare and minor exceptions, existing power developments in these states are far in excess of market demands. The Forest Service is being constantly importuned to extend periods of construction on power permits on the plea that there would be no market available for the power if the project were developed. The per capita use of water power in electrical development in the three Pacific and the eight Mountain states, is far in excess of that in any other section of the United States, as a whole. The development in the Pacific states is about 180 hp. per 1,000 of population, and in the Mountain states 120 hp. per 1,000 of population, with a balanced average of 160 hp. per thousand. New England, which is next in order, has less than 40 hp. per 1,000 of population, and the whole United States has about 30 hp.

According to the Forester's report, there are 108 water-power projects constructed and in operation in the National Forests, with an average estimated output of 341,276 hp. at minimum stream flow, from which the service received rentals during the past year amounting to $89,000, or at the rate of a trifle more than 26c. per hp.

There were in force on June 30, 1915, 182 permits for power projects in the National Forests, with a combined estimated capacity of 1,261,500 hp. Of these projects 108 were constructed and in operation, with a capacity of 341,276 hp.; 26 projects, with a capacity of 95,639 hp., were under construction; and 48 projects, with an estimated probable output of 824,645 hp., were not begun. Forty-seven applications for additional permits had not been acted upon.

Eliminating the free permits which are for small and unimportant power sites, these figures make it appear that, despite the Forester's opinion, no water powers of any considerable size have been constructed under the revocable permits now granted by the Forest Service. On the basis of the figures in the report, it is shown that the power plants in the forests now in operation average only 5,580 hp. output each, that the 15 under construction will have an average output of only 6,633 hp. each, while the 34 projects for which permits have been granted, but which are not under construction, would have an average output of more than 22,000 hp. apiece. These figures, in connection with Mr. Graves' conclusions, are of large interest to those interested in water-power legislation.

Against the opinion expressed by Mr. Graves it has been maintained that many large water-power developments in the West are being deferred because they cannot be financed under the present laws, which permit only revocable permits to be granted for the use of power sites in the National Forests or on the public domain. This view has been expressed also by President Wilson, by the Secretary of the Interior and the Secretary of War, and appears to be sustained by the figures in the Forester's report, which show that while 75 projects, with a combined possible output of 425,000 hp., or an average of less than 6,000 hp. each, have been built or are being built under the present laws, there are 34 other projects, with a combined possible output of three-quarters of a million horsepower, or an average of more than 22,000 hp. each, that have not been built and are not being built.

It is known that a number of large power projects, including one of 250,000 hp., have been surveyed and made the subject of considerable preliminary work, under the present revocable permits and that the promoters are merely holding their rights under such permits until a more liberal law is passed which will enable them to finance the construction of these projects.

Hydro-Electric Development in Central New York

Application has been made to the up-state Public Service Commission for approval of the financial arrangements for a large hydro-electric development at Seneca Falls, which will furnish power to the Central New York Gas and Electric Co. and the Empire Gas and Electric Co., serving the cities and villages of Wayne, Ontario, Seneca and adjoining counties. The Seneca Power Corporation, which will do the actual work of installing this new station in Seneca Falls, asks to increase its capital stock from $5,000 to $1,600,000, and to issue the $450,000 of bonds. When the plant is completed it will be leased to the Central New York Gas and Electric Co., the lease guaranteed by the Empire Coke Co., which owns both of the distributing companies that will take the new power. Much of the money raised from this issue of capital securities will have to be paid for the real estate and water rights.

Massachusetts Refrigeration Rules for All Plants

The following is a bill introduced in the Massachusetts legislature, which will likely become law:

Section 1. All refrigerating plants shall be of such construction and equipped with such devices as may be necessary to make such installation and operation reasonably safe.

Sec. 2. The Board of Boiler Rules shall formulate rules for the said purpose.

Sec. 3. The rules so formulated shall have the force of law and shall be printed and furnished to those requesting them by the Boiler Inspection Department.

Sec. 4. Any changes in the rules so formulated by the Board of Boiler Rules shall be made in accordance with Section 26 of Chapter 465 of the Acts of the Year 1907, as amended by Section 2 of Chapter 393 of the Acts of the Year 1909.

Sec. 5. The provisions of this act shall be enforced by the Boiler Inspection Department of the District Police, and all persons, firms or corporations violating the provisions of this act shall be punished in accordance with Section 86 of Chapter 102 of the Revised Laws, as amended by Section 3 of Chapter 310 of the Acts of the Year 1905.

Sec. 6. The Board of Boiler Rules is hereby authorized to expend a sum not exceeding $1,000 in conducting the necessary investigations and tests and for clerical service in carrying out the provisions of this act.

Sec. 7. This act shall take effect upon its passage.

This means, of course, that the Board of Boiler Rules is to be given authority to regulate the use of all refrigerants used in any kind or type of refrigerating system. The rules now in force apply only to the compression system.

Louisville Generating Capacity Will Be Increased

To meet the rapidly increasing demands for electric light and power in Louisville, the Louisville Gas and Electric Co. has found it necessary to provide increased generating capacity at its Waterside station.

The improvements, which will be in charge of the engineering department of H. M. Byllesby & Co., will include an addition to the present building, installation of a new 15,000-kw. General Electric steam-turbine generating unit with Worthington condensing equipment, four new Babcock & Wilcox boilers equipped with underfeed forced-draft stokers, switchboard, etc. The building will be fireproof throughout. The entire equipment will be the most modern and will effect an appreciable saving in operating cost. This improvement comes within a year of the last previous enlargement of generating capacity, a 6,500-kw. unit with the necessary boiler capacity and other equipment having been installed in the summer of 1915. The new construction has been started, and it is expected that the apparatus will be in service in time for next winter's load. When the present plans have been carried out, the company will have an electric generating capacity of 35,000 kw.

PERSONALS

John L. Harper, chief engineer for the Hydraulic Power Co., Inc., of Niagara Falls, N. Y., has been appointed supervising engineer of the Niagara Falls Grade Crossings Commission.

William A. Cowell, formerly designer and checker with the McIntosh & Seymour Corporation of Auburn, N. Y., has accepted the position of chief draftsman with the William Tod Co., of Youngstown, Ohio.

Frank G. Philo has resigned as boiler-room engineer of the Corn Products Refining Co., Edgewater, N. J., to become efficiency engineer of the Hauto and Harwood plants of the Lehigh Navigation Electric Co.

OBITUARY

GEORGE A. MACBETH

George Alexander Macbeth, president of the Macbeth-Evans Glass Co., for 45 years a glass manufacturer in Pittsburgh, died Feb. 11. Mr. Macbeth was recognized as one of the foremost manufacturers of scientific glass in America. He was a member of the board of trustees of the Carnegie Institute and for years was chairman of the library committee. He was born in Urbana, Ohio. In 1872 he organized the George A. Macbeth Glass Co. In 1899 his company consolidated with the Thomas Evans Glass Co., forming the Macbeth-Evans Glass Co. Mr. Macbeth was elected president and held that position until his death. He was the first American manufacturer to exhibit optical glass. In his initial exhibit at the World's Columbian Exposition in 1894, he won a medal. He was the first in the United States to manufacture lighthouse lenses, and under his direction were manufactured the lamps used to illuminate the Panama Canal.

JAMES D. FARASEY

James D. Farasey, nationally prominent in the boilermaking industry, died Jan. 25, following a surgical operation. At the time of his death he was the owner of the H. E. Teachout Boiler Works, Cleveland, Ohio, which he acquired in 1892. He was born in Cleveland in 1858 and received his early education in the public and parochial schools of that city, after which he attended the University of Dublin, Ireland.

After a few years in marine and railroad office work, he first engaged in the boiler business in 1887, being associated with the late D. Connelly, of Cleveland. Always active in the American Boiler Manufacturers Association, giving freely of both his time and money, appreciation of his efforts was shown by electing him secretary, which post he still held after over fifteen years of continuous service, when he died.

Improvement of the standard of quality and workmanship and uniformity of boiler construction were among the things for which he worked most zealously, and he was largely responsible for getting the National Tubular Boiler Manufacturers' Association and the American Boiler Manufacturers' Association to join forces in an endeavor to obtain legislation and its enforcement toward securing national uniform boiler-construction and inspection laws.

Mr. Farasey leaves a wife, a daughter and four sons. The eldest son, J. D. Farasey, Jr., will succeed to the management of his father's business.

TRADE CATALOGS

Condit Electrical Mfg. Co., Boston, Mass. Bulletins. Oil switches and circuit breaker. Illustrated.

The Scranton Pump Co., Scranton, Penn. Bulletin No. 106. Triplex plunger pump. Illustrated, 8 pp., 6x9 in.

Joseph Dixon Crucible Co., Jersey City, N. J. Booklet. "The Proper Care of Belts." Illustrated, 24 pp., 6x9 in.

Wheeler Condenser & Engineering Co., Carteret, N. J. Bulletin 108-A. Centrifugal pumps. Illustrated, 34 pp., 6x9 in.

Sanford Riley Stoker Co., Ltd., Worcester, Mass. Catalog. Riley self-dumping underfeed stoker. Illustrated, 30 pp., 6x9 in.

Armstrong Cork Co., Pittsburgh, Penn. Folder. "Applying the X-Ray." Insulating materials for cold-storage plants. Illustrated.

The Toledo Pipe Threading Machine Co., Toledo, Ohio. Catalog. Pipe threading and cutting devices. Illustrated, 72 pp., 4x7 in.

The Brown Hoisting Machinery Co., Cleveland, Ohio. Catalog D. Tramrail systems, trolleys, electric hoists. Illustrated, 64 pp., 6x9 in.

Southwark Foundry & Machine Co., Philadelphia, Penn. Catalog. Southwark-Harris oil engine, Diesel type. Illustrated, 42 pp., 8½x11 in.

The C. E. Squires Co., E. 40th St. and Kelley Ave., Cleveland, O. Catalog. Steam traps, reducing valves, pump governors, etc. Illustrated, 46 pp., 9x12 in.

NEW PUBLICATIONS

INVENTIONS AND PATENTS. By Philip E. Edelman. Published by D. Van Nostrand Co., 25 Park Place, New York City. Cloth; 288 pages; 5x8 in. Price, $1.50 net.

This book is intended for persons interested in any way in patents—inventors, investors or laymen—since there is a general misunderstanding or incomplete understanding of the patent system. Beginning with the origin and development of the patent system, the present organization of the office and its methods are outlined. Patent attorneys and what may be expected of them by their clients are dealt with in a frank and apparently impartial manner. Inventors and alleged inventors are accorded the same frank treatment as the attorneys. The various steps in securing a patent are set forth, from the preliminary search to determine the probable patentability on throughout the entire procedure, followed by suggestions on how to utilize or dispose of patent rights. The chapter on infringements, which does not present to the would-be inventor an entirely rosy outlook, closes with the statement that "under the present statutes such procedure and liability to such procedure is a dead weight upon the shoulders of honest inventors and tends to defeat the very purpose of the constitution, namely, to encourage invention."

About 65 pages at the last of the book are devoted to abridgments of office and court decisions in important cases, including disbarment of attorneys from practice before the Patent Office and violations of the established rules of the office through ignorance or design in some cases seriously affecting the application. The author, in a note at the beginning of this section, states that while these abridgments are far from complete, it is thought that they will be of value in supplementing the matter in the text.

The impression remaining after reading this book is that the author has made an honest effort to present facts and matter of value treated apparently without sinister motives, therefore in an unbiased manner, with a pleasing display of familiarity with the subject.

Recent Court Decisions

Digested by A. L. H. STREET

Damages Caused by Dams—One who owns land through which a stream runs is entitled to damages resulting from interference with his right to use a ford in passing from one side to the other, in operation of a dam by a power company in the stream. Right of action for damages would "outlaw" six years after commencement of injury resulting from a permanent effect produced by the dam, but where, as in this case, the injury is caused only occasionally and by the operation of generators, a new cause of action arises every time use of the ford is interrupted. (South Carolina Supreme Court, Fewell vs. Catawba Power Co., 86 "Southeastern Reporter," 947.)

Liability for Boiler Explosion—The mere fact that a steam boiler explodes, resulting in injury to an employee or other

person, does not raise a presumption of negligence in the operation of the boiler so as to make the owner of it liable in damages, holds the Kentucky Court of Appeals in the recent case of Feltner vs. Mason & Hurst Co., 179 "Southwestern Reporter," 222. The plaintiff, a water boy, was talking to the fireman of a boiler that was being used in the excavation of a tunnel when the boiler exploded. Suit brought on account of the accident resulted in favor of the plaintiff, but on review the Court of Appeals reversed the judgment on the ground that there was on the part of the employer no proof of negligence to which the explosion might fairly be attributed. The higher court said:

Manifestly, if the water is permitted to get too low in any boiler and cold water is turned in upon high steam pressure, an explosion will result, but . . . there is no proof about the stage of the water in the boiler or the amount of steam pressure or of any attempt to turn water into the boiler. . . . The only thing established is the fact of the explosion and the condition of the stay-bolts and crown-sheet afterward—a condition common to most boiler explosions, negligent or not. . . . "The fact of an explosion of a steam boiler creates no presumption of negligence. . . . Instances are not infrequent of steam-boiler explosions where there has been no want of ordinary care and skill in their management, and even when there has been the greatest care; and explosions of steam boilers have happened of so mysterious a character that they could not, with confidence, be assigned to any known cause."

ENGINEERING AFFAIRS

Association No. 5, N. A. S. E., Hartford, Conn., was addressed at at its last meeting by A. C. Lippincott, of the E. Keeler Boiler Co., Williamsport, Penn. By means of a glass model the circulation in the Keeler boiler was demonstrated.

The American Institute of Steam Boiler Inspectors of New York City held its annual meeting and election of officers Jan. 28. L. A. Turnbull was elected president; F. C. Nugent, vice-president; M. Fogarty, treasurer; and J. H. Pollard, secretary.

Boston Engineers Dine—Tuesday evening, Feb. 8, the American Society of Mechanical Engineers, the American Institute of Electrical Engineers and the Boston Society of Civil Engineers held their seventh annual banquet in the auditorium of the City Club Building, Boston. The affair was by far the largest and best that these engineers have yet held. The subject on which all except Dr. John A. Brashear spoke was preparedness, and the speakers were: Samuel W. McCall, governor of Massachusetts; Col. W. E. Craighill, U. S. A.; William Barclay Parsons, New York City; Calvin W. Rice, secretary of the American Society of Mechanical Engineers, and John R. Freeman, Providence, who recently inspected the Panama Canal slides in connection with the National Academy of Science. Doctor Brashear gave a most interesting illustrated talk on astronomy and telescopes.

BUSINESS ITEMS

Edward F. Hasson, formerly manager of the General Specialty Co., of Buffalo, N. Y., has become associated with the Advance Machinery & Supply Co., of Denver, Colo., as advertising manager.

A new branch office has just been established at San Francisco, Cal., by the Bristol Company of Waterbury, Conn., at 727 Rialto Bldg. Mr. B. J. Klein has been appointed Pacific district manager.

Mr. Waldemar R. Kremer was appointed general sales manager of the Vilter Manufacturing Co., Milwaukee, Wis., at the recent meeting of the board of directors, succeeding the late Fred Ulrich.

Mr. F. Landolt, 7 Via Virtruvois, Milan, Italy, wishes to act as agent in Italy for American-made engines, boilers, electrical generators and motors, and all power plant apparatus. Manufacturers interested can send catalogs (they may be in English) and prices direct.

Announcement was recently made of the formation of the Pittsburgh and Seaboard Engineering Company, a consolidation of the Robert Wetherill Company, of Chester, Penn., the Riverside Engine & Machine Co., of Oil City, and the Kennedy-Stroh Corporation, of Pittsburgh.

The Toledo Pipe Threading Machine Co., Toledo, Ohio, has just published a new catalogue and hand-book which it will be glad to send to anyone interested in pipe threading, on request. A considerable portion of the book shows jobs on which "Toledo" tools have been used and the tools in actual operation.

Wm. B. Scaife & Sons Co., Pittsburgh, Penn., builders of the "We-Fu-Go" intermittent water softening and purifying apparatus, have recently contracted with the Standard Oil Co., of Ohio, to install a 30,000-gal. per hr. system at No. 1 works, and a 15,000-gal. per hr. system at No. 2 works in Cleveland. They are also under contrate to install a 74,000-gal. per hr. system for Corrigan, McKinney & Company at the plant of the River Furnace Co., Cleveland, Ohio.

Classified Ads

Positions Wanted
Positions Open
Civil Service Work
Employment Agencies
Labor Bureaus
Business Opportunities
For Sale
Wanted
Agents and Salesmen
Contract Work
Miscellaneous
Educational
Books
Proposals

RATES: Positions Wanted, 3 cents a word, minimum charge 50 cents an insertion, payable in advance. Other advertisements, 5 cents a word, minimum charge $1.00. Count 4 words for blind address care of our New York or Chicago offices. Advertisements for bids $3.60 an inch.

ANSWERS addressed to us at 10th Ave. and 36th St., New York or 1144 Monadnock Block, Chicago will be forwarded without charge (excepting circulars or similar literature).

IMPORTANT: Original letters of recommendation or other papers of value should not be enclosed to unknown correspondents—send copies. Advertisers' names will not be furnished under any circumstances. Copy received until 10 A.M. Tuesday for following Tuesday's issue. P

Note: Copy for the issue of Feb. 22 is required one day earlier than noted above.

POSITIONS OPEN

TWO OPERATORS wanted, one repair man who can set valves on twin-tandem gas engines, for an electric power house in Pennsylvania. P705—Power.

OPERATOR wanted immediately for producer-gas gas plant; familiar with AC switchboard; location Connecticut; in answering state age, experience and salary. P719—Power.

SEVERAL FIRST-CLASS DRAFTSMEN wanted at once, of general mill and blast furnace experience; state age, experience, present salary and salary wanted in first letter; also when available; central location, Pittsburgh. P687—Power.

SEVERAL DRAFTSMEN wanted at once, experienced in power plant and general piping work; state age, experience, present salary and salary wanted in first letter; also when available; central location, Pittsburgh. P688—Power.

AN ASSISTANT ENGINEER wanted in large power plant near Philadelphia; must be able to prove experience in operation of the leading turbines, Corliss engines and boilers; must have machine-shop experience and be willing to work. P694—Power.

WELL-ESTABLISHED MANUFACTURER making entirely necessary specialty for power plants desires live, wide awake, well educated salesman; salary proposition or as a side line; technical experience preferred but not necessary; state references and experience to P713—Power.

MAN wanted to take charge of erection and maintenance of machines and power equipment in tannery located in small town near city; permanent position for the right man; in answering give full particulars regarding age, experience and salary considered. P696—Power.

ENGINEER CHIEF; married; one who can show results in boiler room; acquainted with switchboards, Heine boilers, Curtis and Allis-Chalmers turbines; two other ordinary engineers employed; Illinois town 10,000 to 15,000; state age, experience and salary expected; steady job; letter confidential. P717—Power.

FIRST-CLASS SALESMAN wanted by well known company to specialize on greases, selling direct to factories consuming medium and large quantity of grease; man familiar with greases not necessary, but it is desirable that he be familiar with general machinery, engines, etc; salesmanship is very essential; must be qualified to talk with superintendents and engineers; also close contracts with purchasing officials; excellent opportunity for right man; give complete details, experience, salary expected at start, etc., in first letter. P711—Power.

Employment Agencies

CORRESPONDENT

THE UNDERSIGNED plans and conducts correspondence for positions in technical, manufacturing and professional lines; $2500 to $15,000 men exclusively; complete privacy assured; no commission charged—only service fee and postage. Send name and address only, in confidence, for prefatory details. R. W. Bixby (established 1910), P1 Niagara Square, Buffalo, N. Y.

POSITIONS WANTED

CHIEF ENGINEER open for position; 20 years' experience; present position 5,000-hp. plant; best of reference. PW703—Power.

POWER-PLANT OPERATING ENGINEER or assistant; licensed man; experienced in the care and operation of engines, boilers and auxiliary equipment; immediately available; location immaterial. PW678—Power.

CHIEF ENGINEER in a small plant or operator in a large plant; 12 years' experience with steam, electric, refrigerating, pumping and condensing equipment; technical education; first-class license and references; married; age 31; employed. PW706—Power.

MECHANICAL ENGINEER, with engineering and operating experience in connection with large steam-power plants, desires position such as power or mechanical superintendent or chief mechanical engineer; now holding executive position. PW708—Power.

SUPERINTENDENT for heating and power contractor wishes to make a change; open for engagement about Mar. 1; 19 years experience installing power, heating and automatic sprinkler apparatus; best of references; age 37. PW712—Power.

ENGINEER, third grade New York City license, wants position in charge or as assistant in small plant; familiar with refrigerating and electrical apparatus, hydraulic and electric elevators; five years in last position in charge of plant; references. PW715—Power.

CHIEF ENGINEER OR ASSISTANT; 12 years' experience on Corliss and high-speed engines, turbines, a.c. and d.c. current, water- and fire-tube boilers, wishes position where good results is wanted; married and of good habits; best of references. PW716—Power.

YOUNG MECHANICAL ENGINEER, Greek, graduate of technical university and thorough theoretical and practical study, special on hydrodynamics, thermodynamics, telectrotechnics, two years' practice on ship yard, knowing French, German, English, seeks position in large constructing factory. PW718—Power.

CHIEF OPERATING ENGINEER, at present employed, desires change; central or Southern States preferred; capable of taking charge of big plant; experienced with pumping station and power station units, either reciprocating or turbine (Curtis), and all equipment; would consider big manufacturing plant; familiar with rope drive; good executive ability as well as practical mechanic on repair and renewal; in perfect health and available in from 30 to 60 days' notice; A1 references. PW710—Power.

WANTED

MANUFACTURER wants either patented or patentable ideas on boiler and engine room specialties; cash or royalty basis. W676—Power.

STEAM TURBINES—Chicago steam and hydraulic machinery house desires to add line of steam turbines. Correspondence from manufacturers with ample facilities requested. W701—Power, Chicago.

AGENTS AND SALESMEN

AGENTS to handle boiler-efficiency device; liberal commission and full coöperation. W686—Power, Chicago.

AGENTS wanted to handle a new patented grate bar on commission; state experience, location, how long established. W685—Power.

SALES AGENCY for western New York can handle a few more mechanical appliances of merit. W704—Power.

AGENTS handling engine and boiler room specialties, in every section, for side line, paying large commissions. Give experience, lines carried and territory covered. W390—Power.

AGENTS on commission to sell our Shaking Grates; we will install grates on trial or put in on test at our expense with any grate made. Address Armstrong Mfg. Co., Springfield, Ohio.

AGENTS on commission to sell the new and successful duplex return steam trap; join a rapidly growing organization. Address American Duplex Steam Trap Co., 413 Moffat Block, Detroit, Mich.

A LIVE MASSACHUSETTS CONCERN would like to correspond with good live manufacturers that would be willing to grant exclusive teritory on steam specialties in New England States. W714—Power.

MISCELLANEOUS

PATENT ATTORNEYS

PATENTS. C. L. Parker, patent attorney, formerly member Examining Corps, U. S. Patent Office, McGill Bldg., Washington, D. C. Inventor's handbook sent upon request.

IS YOUR INVENTION VALUABLE? Ask A. P. Connor, electrical, mechanical engineer (ex-chief electrical engineer for New York). Patent attorney. Lawyer. Carroll St., S. E., Washington, D. C.

For Sale

Second Hand Equipment

Rates: Less than 4 insertions 75 cents per line—4 to 11 insertions 70 cents per line—12 or more insertions 65 cents per line

Equipment Wanted items appear at the end of this list.

ADVERTISERS' NAMES are abbreviated in most of these items. Complete names and addresses are as follows:

MANHATTAN Rubber Mfg. Co., Passaic, N. J.—All equipment advertised may be seen in daily operation at the company's plant. Delivery Mar. 15, 1916, f.o.b. D., L. & W. R.R., Passaic.

NEW RIVER CO., The, MacDonald, W. Va.

ENGINES, GAS

Westinghouse vertical, 40 hp., now running; in best possible condition. Selling because of purchase of a larger unit. Delivery immediately.—The Acklin Stamping Co., Toledo, O.

ENGINES, STEAM

Horizontal and Vertical, capacities 6 to 320 H.P. All good makes.—NEW RIVER.

1—14″x36″ Allis-Chalmers Corliss, 1890 type, R.H., fine condition.—L. F. Seyfert's Sons, Inc., 437 N. 3rd St., Phila., Pa.

Fitchburg left hand, horizontal, tandem compound; cylinders 17″ and 28″ dia., 36″ stroke, 120 r.p.m., heavy tangye frame; double ported piston valves; flywheel 14′ dia., 24″ face, with governor and outboard bearing, $3,000.—MANHATTAN.

GENERATING UNITS

Direct current, 250-500 V., cap. up to 250 KW.—NEW RIVER.

One 220 KW., A.C., 60-cycle, 2,200-volt, two-phase generator, direct connected to 200-r.p.m. Buckeye engine, with transformers for supplying 2,200 volts, 3-phase, complete with barometric condenser, motor-driven condenser pump, switchboard instruments and instrument transformers. Complete details upon application to WISCONSIN GAS & ELECTRIC CO., Racine, Wis.

Engine and Generator—One Hamilton Corliss 18x36x42″ horizontal cross compound engine with 14x16″ cast iron flywheel; direct connected to Westinghouse 580-kw. generator, 440 v., 761 amp., 3-phase, 25-cycle, 107 r.p.m. Generator is revolving field; the Exciter is steam driven. No Switchboard with this outfit. Engine now running condensing. All of the equipment, such as pumps and piping, is in connection with the Engine. The condenser is of the surface type. 140 lb. steam pressure used. Floor space 21 ft. 8 inches wide—28 ft. long over all. Equipment has been in operation five years and can be seen in operation during February and March at our Cedar Rapids Mill. For price and full information address National Oats Co., St. Louis, Mo.

One cross-compound Buckeye engine with high-pressure auxiliary cylinder attached; can be used condensing or non-condensing for steam or hot-water heating. The size of this engine is 18¾″ dia. high-pressure cylinder, dia. low-pressure cylinder 36″, stroke 33″, r.p.m. 138; auxiliary cylinder 14½″ dia., 33″ stroke. This engine is direct connected to a Westinghouse revolving field type, 2,300 volt, 400-kw., 60-cycle, 2-phase generator. Also one tandem compound Buckeye engine, 20x 36x33, 138 r.p.m., direct connected to 400-kw. Westinghouse surface wound armature, type 2-phase, 60-cycle, 2,300-volt generator.—Iowa Railway & Light Co., Cedar Rapids, Iowa.

GENERATORS

Sprague belted, D.C., type S, 150 kw., 120-125-V., 1,200 amp., 550 r.p.m., with base, slide rails and voltage regulator, $800.—MANHATTAN.

METERS, STEAM

One 1″ St. St. John meter in perfect condition.—L. J. Wing Mfg. Co., 352 West 13th St., N. Y. City.

PIPE AND FITTINGS

Pipe and fittings, screwed & flanged, 7 to 18″.—NEW RIVER.

PUMPS

High head, general service and boiler feed.—NEW RIVER.

Bids received until May 3, 1916.

Receiver's Sale

OF ALL THE PROPERTY OF THE

SOUTHERN IOWA RAILWAY & LIGHT COMPANY

On the third day of May, 1916, at two o'clock in the afternoon, at the North door of the Court House in Albia, Iowa. All the real, personal and mixed property of the Southern Iowa Railway and Light Company and the Albia Gas Company will be sold at a Receiver's sale to the highest bidder.

The property consists of Central Station buildings, Machinery and equipment, Car Barns and contents. Rolling Stock, Rights of Way, Rails, Ties, etc., of ten miles of street and interurban lines, Transmission and service lines, Heating Mains and service equipment, Gas Plant buildings, Machinery and equipment, Gas Mains and service equipment.

The Property has been operated by the Receiver since June 8, 1915. Statements of earnings and expenses for the period the Receiver has been in charge will be furnished interested parties.

Figures covering a recent appraisal of the property are also available. ALFRED C. MUELLER, Rec.,

Albia, Iowa.